Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

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Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

AUGUST, 1915.

AN EASY METHOD OF FINDING THE APPROXIMATE LONGITUDE OF THE PLANETS.

By PROFESSOR HERBERT CHATLEY, D.Sc. (Lond.), M.I.C.E.I., A.F.Aë.S.

There are many problems in astronomy, especially in connection with historical questions, in which it is not sufficiently accurate to assume that the planetary orbits are circular; on the other hand, the process of computing the true elliptic longitudes is intricate, very tedious, and, moreover, liable to small errors arising from the perturbations.

It is the object of this present article to give a method of computing the elliptic longitudes to within a few minutes of arc without employing transcendental functions or long Fourier series. A few words are necessary in preliminary explanation, and to show the assumptions on which the formula is based.

Kepler's first two laws state that each of the planets revolves in an elliptical orbit, the Sun being situated at one of the foci, and that the radius-vector, or line connecting the planet with the Sun, sweeps over equal areas in equal times. From this it follows that in one-quarter of the periodic time (reckoning from perihelion) the radius-vector swings through *more than* a right angle, making the area swept over by it equal to one-quarter of that of the whole ellipse (see Figure 200). Similarly in the second quarter of the periodic time the radius-vector sweeps over *less than* a right angle, again covering one-quarter of the area of the ellipse. In the third and fourth quarters the conditions are the same as in the second and the first. From this it appears that the difference between the angle passed through by the radius-vector in an ellipse and that passed through in a circle (in which the angular velocity would be constant) is positive at the end of the first quarter, zero at the second quarter, negative at the third quarter, and again zero at perihelion; thus the angular excess for uniform rotation varies periodically, passing through a complete cycle during each revolution. *Assuming* the variation to be harmonic, if the maximum angular excess is known, a very simple formula can be produced for the heliocentric longitude as follows: Heliocentric longitude=longitude of perihelion+(mean angular velocity per day×the time in days since perihelion)+(maximum angular excess×sine of the mean angular velocity×the time in days since aphelion); or

$$L=L_0+\mu t+A\,.\sin(\mu t).$$

The angular excess A is a function of the eccentricity, and, if the eccentricity is less than ·3, is closely given by the following formula:

$$A=2\tan^{-1}\left\{\sqrt{\frac{1+e}{1-e}}\tan\left(\frac{\pi}{4}+\frac{e}{2}\right)\right\}-90^\circ=2e$$

radians nearly.

It is convenient to express this angular excess as an angle of which the sine$=ke$, where k is a coefficient and e is the eccentricity, and it is

interesting to point out that k cannot be less than unity. This may be shown as follows.

Since the linear velocity is greatest at perihelion, the mean velocity in the perihelion half of the ellipse is greater than that of the aphelion half; therefore the aphelion half is described in less time than the perihelion half. When the planet arrives at the half-way point the radius-vector is equal to the semi-major axis of the ellipse, and is inclined to the minor axis at an angle the sine of which equals the eccentricity. At this moment the quarter-period has not been completed, and the radius-vector has swung through 90°+arc (sin e), thus proving that the angular excess in the quarter-period A is more than arc (sin e) (see Figure 201).

The linear velocity of the planet varies inversely as the perpendicular from the focus to the tangent. This perpendicular is equal to the semi-major axis when the radius-vector has swung through 90° + arc (sin $1\frac{1}{2}e$) approximately; the velocity is then equivalent to the constant velocity, which would occur if the orbit were circular and of a radius equal to the semi-major axis of the ellipse; k (see Figure 202) is thus more than $1\frac{1}{2}$, depending on the eccentricity.

k is almost exactly equal to 2, so that $A=2e$ radians nearly.

In making calculations on this basis two corrections have to be applied. First, in each year the line of the apsides must be advanced through a small angle which is positive for all the planets except Uranus and Neptune (almost zero for Jupiter and Saturn). Second, on account of the precession of the equinoxes, the first point of Aries from which the longitudes are reckoned must be set back 50″ each year, thereby increasing the longitude by the same amount (see Figure 203).

In order to find the geocentric longitude of a planet, the heliocentric longitude of the planet and of the Earth must be calculated, and also the radius-vector of each. The radius-vector is found from the following formula:

$$r=\frac{a\,(1-e^2)}{1+e\cos\theta} \qquad [a = \text{semi-major axis or mean distance.}]$$

The geocentric longitude may then be found by the solution of a plane triangle, as shown in Figure 204.

Small discrepancies will be found between the values so calculated and those given in the standard ephemerides, as the angular excess is not perfectly harmonic; but the errors are not cumulative to any appreciable extent, and the calculations can be extended over thousands of years forwards or backwards without an error of more than a degree.

TABLE 40.

Table of Particulars required for computation of Heliocentric Longitudes.
[Based on Newcomb's Tables.]

—	☿	♀	⊕	♂	♃	♄	♅	♆
Eccentricity ...	0·205614	0·006821	0·016751	0·093309	0·048254	0·056061	0·047044	0·008533
A=$\sin^{-1}(2e)$ ...	22° 52′ * [<$\sin^{-1}2e$]	0° 46′	1° 55′	10° 45′	5° 32′	6° 36′	5° 24′	0° 58′
Semi-major axis=a	0·387099	0·72333	1·0	1·52369	5·2028	9·5388	19·19096	30·07067
Heliocentric longitude of perihelion at 1900·0... ...	75° 54′	130° 10′ [To find aphelion add 180°]	101° 13′	334° 13′	12° 36′	90° 49′	169° 3′	43° 45′
Change of perihelion per annum, *including* precession of equinoxes ...	0° 0′ 56″·4	0° 0′ 51″·6	0° 1′ 2″·4	0° 1′ 6″	0° 0′ 49″·2	0° 0′ 50″·4	−0° 2′ 8″·4	−0° 2′ 42″
Ditto, *not* including precession ...	0° 0′ 6″·2	0° 0′ 1″·4	0° 0′ 12″·2	0° 0′ 15″·8	−0° 0′ 1″	+0° 0′ 0″·2	−0° 3′ 0″·6	−0° 3′ 32″·2
Mean heliocentric angular velocity per day	4°·0927	1°·6021	0°·9856	0°·52403	0°·083091	0°·03346	0°·01177	0°·00602
Heliocentric longitude 1910·0 ...	3° 32′	73° 53′	99° 17′	47° 39′	181° 43′	28° 56′	286° 42′	107° 1′

Note.—As the inclinations of the orbits to the plane of the ecliptic are small, the errors due to this cause are very minute.

* The difference between A and $\sin^{-1}(2e)$ is here appreciable on account of the large eccentricity of Mercury.

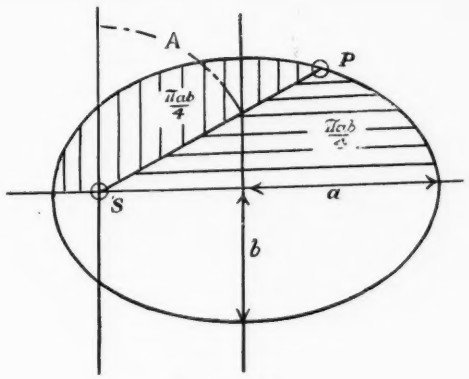

FIGURE 200.

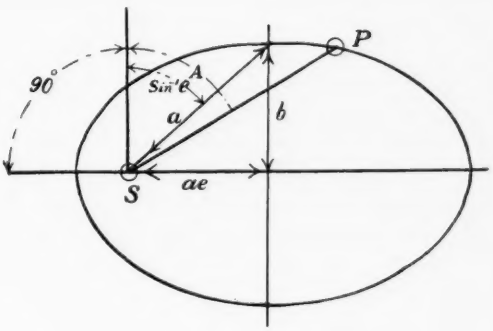

FIGURE 201.

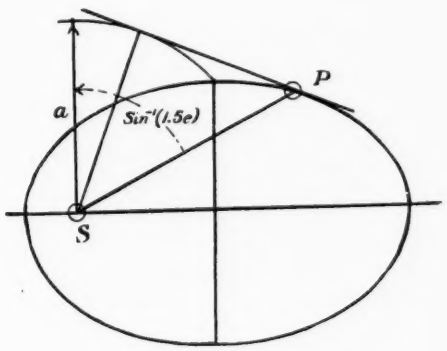

FIGURE 202.

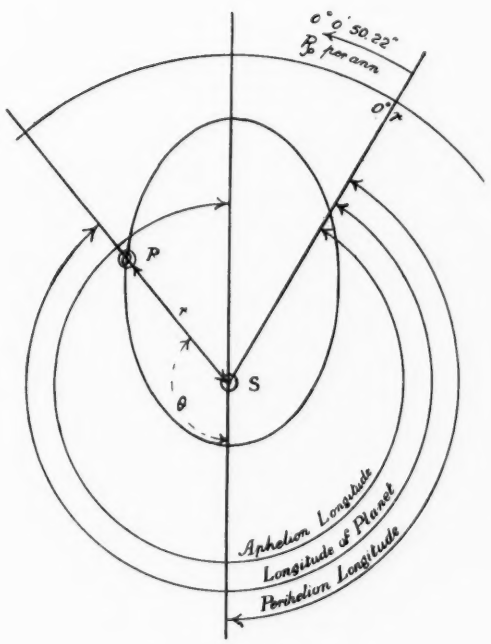

FIGURE 203.

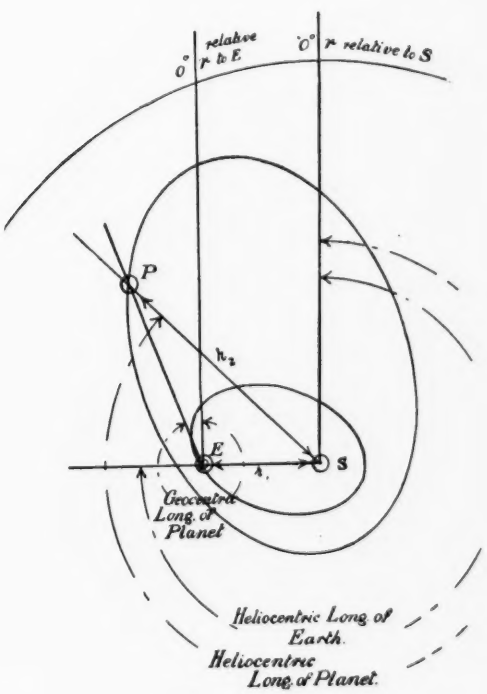

FIGURE 204.

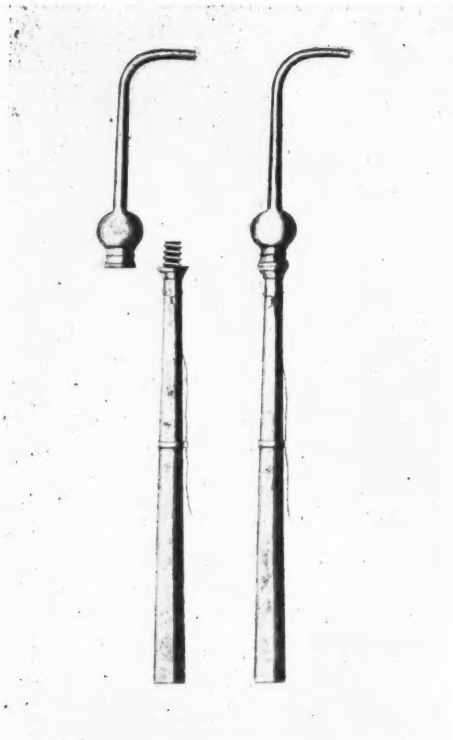

FIGURE 205. Cronstedt's mouth blowpipe, 1750.
The first blowpipe used for chemical analysis.
From the "System of Mineralogy."

FIGURE 206. Newman's blowpipe, 1816.
Designed to obviate the difficulty of blowing with the mouth; used with compressed gases as the first oxyhydrogen blowpipe.
(From an example in the Science Museum, South Kensington.)

FIGURE 207. Gurney's safety oxyhydrogen blowpipe, 1823.
(From an example in the Science Museum, South Kensington.)

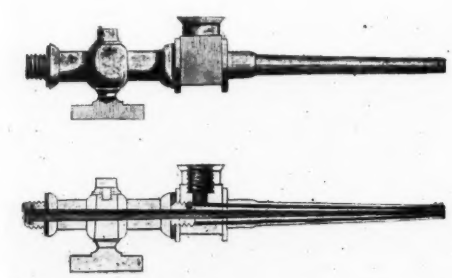

FIGURE 208. Daniell's oxhydrogen blowpipe, 1833.
(From the "Philosophical Magazine.")

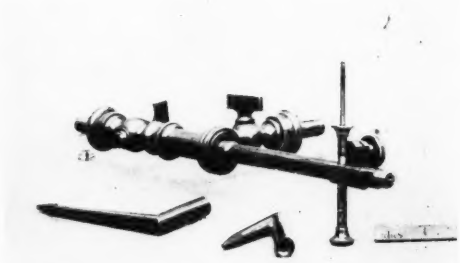

FIGURE 209. Maughan's oxyhydrogen blowpipe, 1835.
(From an example in the Science Museum, South Kensington.)

THE HISTORY OF THE BLOWPIPE.

By S. C. BRADFORD, B.Sc.

"FERTILE in expedient and powerful in agency as the combined efforts of genius have contributed to render modern chemistry, it may perhaps be fairly doubted, when we except the mighty voltaic achievements which enabled our celebrated Davy to decompose the alkalies and elucidate the basis of the earths, if, in the appliances of this most universal science, we can rank one superior or even equal in its general operation to that which uniformly obtains from the use of the oxyhydrogen blowpipe." These words, from the pen of Weeks in 1840, remain entirely applicable in 1915, and we shall endeavour to trace the gradual evolution by easy and almost inevitable developments from the simplest beginning of this wonderful instrument, which exhibits such small comparison with its ancient form of construction and degree of effect as scarcely to be recognised as belonging to the same class of philosophical apparatus.

The mouth blowpipe was employed by the early Egyptians for urging the fire of small furnaces for goldsmith's work. By a natural transition, it was utilised as an instrument whereby the flame of a lamp or candle could be converted into a species of furnace capable of communicating an intense heat to small bodies placed in the apex by goldsmiths and glass-workers. The German name "Löthrohr" is derived from the former application. The instrument generally consisted of a metal tube, about a quarter of an inch in diameter at one end and tapering towards the other, near which it was curved through 90°, and terminated in a fine jet. The length of the straight part was about eight inches.

In the middle of the 18th century the Swedish mineralogist, Cronstedt, first applied the instrument to analysis (see Figure 205), the substance to be examined being supported on a block of charcoal. In this operation it was often necessary to blow continuously for many minutes, and Cronstedt introduced a spherical enlargement immediately before the bend of the blowpipe for the purpose of retaining the moisture condensed from the breath. With the aid of this simple apparatus the inventor was able greatly to extend our knowledge of mineral substances, and published anonymously, in 1758, his celebrated "Försök til Mineralogie," which laid the foundations of systematic mineralogy. The modest author did not describe his new method, and the first manual on the use of the blowpipe was issued in 1770, by von Engström, as an appendix to the English translation of Cronstedt's treatise.

The importance of this process of analysis was now soon recognised, and its application was extended by Bergman and Gahn, the latter of whom gave the mouth blowpipe the form which was adopted by Berzelius and Plattner, and is still generally used on the Continent, and largely in this country. Gahn's blowpipe consisted essentially of a narrow metal tube, about seven inches long, terminating in a coaxial cylindrical condensing chamber, rather less than half an inch in diameter and one inch in length, near the end of which a side tube carried the air-jet. By constant practice Gahn attained to such a degree of skill in the use of the instrument that by its means he could detect the presence, in a body, of substances which had escaped the most careful contemporary analysis conducted in the wet way. Thus he detected tin in a specimen of the newly discovered oxide of columbium, although less than one per cent. of the former metal was present.

Many modifications of the mouth blowpipe were subsequently introduced. The simplest form, and that still generally used in this country, was designed by Black. This consists of a conical tube expanding gradually from the mouthpiece to a diameter of half an inch at the closed end, where a side tube, terminating in a fine nozzle, is attached at right angles.

The application of the blowpipe to chemical analysis was perfected and systematised by Berzelius, who published his pamphlet, "Ueber die Anwendung des Löthrohrs," in 1820. Harkort was the first to employ the instrument for quantitative estimations, and described his method in his "Probirkunst mit dem Löthrohre," in 1827, while Plattner's comprehensive researches and the publication of his classic, "Probirkunst mit dem Löthrohre," in 1836, developed the art into an important branch of assaying.

As Berzelius remarks, it was "generally supposed that the use of the blowpipe is a difficult operation, that it requires great pulmonary exertion, and may be injurious to the health. Partly for this reason, and partly for want of skill to keep up a continued blast, various contrivances were hit upon to supersede the blowing with the mouth." Several so-called hydrostatic blowpipes were invented, but the only apparatus to which we shall call attention is that designed by Newman, of Lisle Street. The inventor had had occasion to condense air in cavities, and had observed, with some surprise, the length of time required for the compressed air to escape. In conversation with Brooke the latter suggested the employment of the effect in the construction of a blowpipe, which Newman proceeded to carry out. The apparatus (see Figure 206) consists of a rectangular box of sheet copper, $3 \times 3 \times 5\frac{1}{2}$ inches in dimensions, fitted with a condensing syringe to force air into the box, and a jet and stopcock to regulate the stream thrown on to the flame. A few strokes of the piston sufficed to charge the box, which would then supply air with great force in a small but rapid stream for about twenty minutes. Little did the inventor dream at the time of the use to which his instrument would be put. Dr. Clarke, the same year, employed the apparatus to direct a stream of oxygen upon the flame of a spirit lamp, according to Marcet's method. Newman suggested that the ratio of the hydrogen in the alcohol vapour to the oxygen in the blast was not that calculated to produce the highest temperature, and proposed the use of a condensed mixture of oxygen and hydrogen in their combining proportions. Davy had just published his experiments on the miner's safety lamp, in which he had shown that an explosion would not pass along a capillary tube, and on being consulted he gave his assurance that the experiment would be safe. Accordingly, Dr. Clarke adapted a thermometer tube, three inches long and one-eightieth of an inch bore to the jet of the blowpipe, with the result that "a portion of the mixture, being allowed to pass through the orifice of the blowpipe, was ignited at the extremity of the capillary, and such was its exalted temperature that it has banished altogether the character of infusibility from the list of chemical tests to which minerals may be exposed. Platinum melted and iron wire burned with vivid scintillations."

As may be imagined, explosions frequently occurred, and many improvements were suggested. In 1802 Hare had unsuccessfully endeavoured to utilise the flame from a mixture of the two gases passing through separate tubes united at the end. In 1817 Murray used separate reservoirs for oxygen and hydrogen, and the same year Hope invented a jet in which the mixed gases bubbled through oil and passed through folds of wire gauze. It was not until 1823, however, that Gurney showed that the explosion would not pass back along the tube if the gases were issuing with sufficient speed, and that, by allowing a small explosion in a corked cylinder constructed for the purpose between the jet and the reservoir, the diminished pressure caused by blowing out the cork would prevent the further retrograde movement of the flame. Gurney's "Safety Oxyhydrogen Blowpipe" was awarded a gold medal by the Society of Arts. The mixed gases are contained in a small bladder, supported on a table and surmounted by a thin board (see Figure 207), which is tied by light threads to four wires attached to a pressure-board below the table, by which the hand of the

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operator could force the gases through a curved tube dipping under water in the vertical corked explosion cylinder. From this the gases pass through many layers of fine wire gauze to the jet. In the event of an explosion extending to the reservoir, the upper board is so light, and so slightly attached, that no damage could result.

The so-called table blowpipe had long been in use for glass working. It is first described by Kunckel in his "Ars Vitraria" in 1679. Underneath a table were fixed powerful bellows, capable of being actuated by the foot of the operator: a tube coming through the table and ending in a jet directed the blast upon the flame of an oil lamp. It was in this country, in about 1825, that coal-gas first began to be generally used in chemical laboratories, and gas jets were soon found to be preferable for blowpipe work. As it became obvious that the best results were not obtained by directing the air blast at right angles to the flame, attempts were made to give the air- and gas-jets the same direction by combining the mouth blowpipe with the gas burner, and a type was evolved composed of a short brass tube, three-eighths of an inch in diameter, with a side tube for gas supply and a cork at the end through which the nozzle of the blowpipe was introduced. The air-tube was thus coaxial with the burner, as in modern appliances. In some arrangements for table blowpipes the extremity only of the air-tube was introduced into the end of the gas-tube. The exact dates of the introduction of these types are, however, uncertain. Faraday does not mention gas blowpipes in the second edition of his "Chemical Manipulation" in 1830. But in the third edition, published in 1842, he says: "The most useful arrangement is that where the extremity of the air jet is surrounded by the extremity of the tube supplying gas." Soon after this date, Herapath gave the gas blowpipe the form in which, with slight modifications, it is generally used to-day. His arrangement consisted of a vertical tube standing on a heavy foot, and provided with a horizontal side-tube supporting the blowpipe tube on a swivel joint, through which the gas was supplied. The air jet was contained centrally within the blowpipe tube, and connected, by means of a rubber tube, with a bone mouthpiece for blowing. It was an obvious step to attach a mechanical blower, as is now invariably done. A gas blowpipe on trunnions, with central air feed for mechanical blowing, was described in the *Mechanic's Magazine* in 1842. This bears some resemblance, externally, to the compound blowpipe patented by Fletcher in 1881, which has an arrangement whereby any size or character of flame can instantly be obtained by a single movement of a lever, and is at present the most convenient form for glass-blowing and general laboratory purposes.

It is possible that the early combinations of mouth blowpipe and gas burner may have suggested to Daniell, in 1833, the adoption of a concentric inner tube for oxygen in the oxyhydrogen blowpipe (see Figure 208). However this may be, to him is due the credit of having placed in the hands of chemists an instrument in which all possibility of explosion was avoided by allowing the gases to mix only at the moment of their ignition, and which could be used with perfect safety, even by unskilled persons. Compared with the fine nozzles of previous oxyhydrogen blowpipes, a remarkable feature of the Daniell blowpipe is the wide apertures of the tubes, which seem more fitted for use with air and coal-gas than with oxygen and hydrogen. In order to avoid the waste thus occasioned and ensure more perfect mixing of the gases, Maughan, in 1835 (see Figure 209), soldered a brass plate with eight small holes over the end of the hydrogen tube for the purpose of dividing the stream of issuing gas, and ensuring a more perfect mixture with the oxygen delivered from a tube with a narrow orifice passing through a central hole in the plate at the same point where a jet with a small mixing chamber and fine aperture was screwed over the end of the hydrogen tube. Thus was perfected the instrument which has been of such universal application in science and industry.

CORRESPONDENCE.

"THE CHANGE OF CLIMATE AND ITS CAUSE."

To the Editors of "KNOWLEDGE."

SIRS,—In replying to the criticism on "The Change of Climate, and Its Cause,"* which appeared in last month's issue, I should like to make my position more clear. I am not an astronomer, nor can I claim any particular mathematical ability, but I have deeply studied geological subjects.

On finding how geology from time to time was adding evidence to the correctness of Drayson's conclusions, I naturally tried to understand the astronomical attitude to his discovery. Though I am quite aware that on some minor points he laid himself open to criticism, such as in his misconception of what was meant in mathematical terms by the conical movement of the earth's axis, the general trend of his various calculations marked an extraordinary advance in astronomical science, and bore evidence of correctness in the perfect squaring of results with observation.

I am supported in this by the fact that Admiral Sir Algernon de Horsey, who at first set himself the task, as he thought, of disproving Drayson, became finally a convert, and one can judge of the probability of his solutions of the path of the pole of the heavens being the true one by the fact that de Horsey arrived at the same results by correlating various recorded star movements and working the problem backwards, so to speak.

Before answering the criticisms I should like to state the facts which form the groundwork of my present confidence that Drayson's interpretation of the curve of precession (*i.e.*, his "second rotation") is the correct one.

To begin with, it is apparent that the astronomical machinery is out of gear in this particular. Astronomers are unable to determine satisfactorily the cause of the lessening obliquity, There is an assumed ***fixed*** obliquity, which is subject to variation, and the reasons given for this variation are not consistent in the statement of the amount of variation possible, nor consistent with the assumption of a pole of ecliptic centre for the curve of precession. This last assumption, moreover, has led them astray in their attempt to explain the glacial epoch, obliging them to insist on the *alternate* glaciation of the north and south poles. By their own showing this explanation will now have to be abandoned. Nothing is more certain than that the glaciation was simultaneous at both poles.

Drayson enables us to meet all difficulties by defining the real curve and the real centre, by which the decrease in obliquity is satisfactorily accounted for, and a former much greater obliquity indicated, an obliquity quite sufficient to produce a vast accumulation of ice over the temperate regions in both hemispheres at the same time. By the reading of the curve he was enabled to postulate the beginning and the maximum of the extreme cold condition, and its comparatively rapid ending about seven thousand years ago, foretelling and verifying the conclusions at which geologists of late years have independently arrived in a most striking and unexpected manner.

To remove any possible misconception I would state that Drayson's "second rotation" is that movement of the earth which causes the precession of the equinoxes, and introduces no new element, but merely defines the curve.

No astronomer has so far really defined the curve. Consequently, in the last fifty years we have been supplied with varying estimates of the total period of the revolution of the

* E. Marlborough & Co., 51, Old Bailey. Price 1/6.

equinoxes. A curve cannot approach a point outside the curve at a uniform rate, so that different results were obtained according to the particular decade which supplied the basis for computation. Some astronomers assert that the curve is well known, but avoid any definite statements regarding it. Others add statements which belie their assertions. For instance, a distinguished astronomer said: "The motion of the Earth's pole is perfectly understood. For a short time, as a few years, it may be considered as a circle, but for a long time it is not a circle."

In Herschel's "Outlines of Astronomy" we are told that the Earth's axis traces a circle round the pole of the ecliptic as a centre, but varies its distance from this centre 46″ per century.

It appears that astronomers are satisfied to admit that by some coincidence the pole of the ecliptic, though it moved at least 46″ per century towards the pole of the heavens, yet always managed to remain exactly the centre of the circle traced by the pole of the heavens. Then, although the distance of the two poles was, one thousand seven hundred years ago, close on 24°, it is now only 23° 27′, and is consequently a varying quantity; yet this has been considered a constant quantity, fixed at 23° 28′, the pole of the ecliptic being always supposed to be the true centre of a circle, from the circumference of which it was known to vary its distance.

Geometricians will tell us, as does common sense, that if there be a change in obliquity then the pole of the ecliptic cannot be the centre of the circle described by the pole of the heavens; but astronomers, having disregarded for a long time the significance of the evidences of diminishing obliquity, are content to rely on a movement of the plane of the ecliptic to account for it, and it is customary to cite Laplace's investigations as a final answer to all cavil. His conclusions, however, are unsupported by geometry, because there would still be no change in the obliquity if the pole of the ecliptic remained the centre of the circle described by the pole of the heavens. Unfortunately, this inconsistency, having been once admitted as an explanation, without a proper scrutiny of its credentials, has imposed upon one generation after another.

A history of the question shows that, even if there is a movement of the plane of the ecliptic, it is quite undefined, and that the consequent reason for the change in the value of the obliquity rests on the flimsiest of structures. Laplace limited the movement to an angle of 1° 41′ about an "invariable plane," and it became at once a heresy to doubt it. Some years afterwards Leverrier, who was equally illustrious, made fresh calculations, with the result that the angle was stated to be 4° 52′; and what the "British Encyclopaedia" of 1906 now says—I presume with an authority a century ahead of Laplace—is as follows:—

"Attempts have been made by Laplace and his successors to fix certain limits within which the obliquity of the ecliptic shall always be confined. The results thus derived are, however, based on imperfect formulae. When the problem is considered in a rigorous form, it is found that no absolute limits can be set."

Thus one of the main props for keeping up the fiction of a fixed obliquity is knocked away, and the original statement only requires one more "rigorous" investigation to be rejected altogether.

Since the astronomical assumption that we are chiefly concerned about is entirely dependent on this other movement, about which there seems to be such a variety of opinions, no one can assert that the question is in a satisfactory condition, or that "the motion of the Earth's pole is *perfectly understood.*"

The tracing of the curve of the precession movement, in accordance with the conclusions of Newton, is shown under all these aspects to be at variance with fact; and, consequently, an adherence to former assumptions meets trouble in every direction.

How different the character of the curve becomes when traced by the hand of Drayson! The position of the pole of the heavens in its movement round the newly found permanent, and therefore real, centre at once explains the decrease in the obliquity. Ambiguity is no longer necessary. No need for the paradox of a movable centre, nor for the antics of the ecliptic plane. One by one the enigmas of astronomy and geology are cleared up, and in the matte of glacial periods the two sciences have mutual support. Astronomy indicates what ought to have occurred, and geological evidence proves that it did occur, and that the evidence is still visible.

Perhaps the real simplicity of the question will come as the greatest surprise to geologists, who in studying glaciations have grown reconciled to weird theories of volcanic dust, carbonic acid set free, and so on, though none have a single fact to support them. The power with which a knowledge of Drayson's discovery invests anyone in obtaining astronomical results without observation may be doubted by those who will not attempt to investigate his formulae, but geologists who accept his *data* will find ample justification for every statement he has made regarding this last period of earth-history. The *universality* of the glaciations at both poles *at the same period* was the first and greatest proof that the astronomers were wrong, and that Drayson was right. To this have been added other facts which are each in its way telling proofs of the accuracy of his deductions. Resistance to Drayson must break down when the perplexing question of the "submerged forests" stands revealed as the direct outcome in time and place of the condition specified by Drayson's curve. Mr. Clement Reid, without any thought of glaciation or its effects, gives a date for the rise of the sea (which he deems as a submergence of the land) and the probable duration of the process, and thus supplies a convincing and unintentional verification of the nature and duration of the last phase of glaciation as denoted by Drayson.

Your critic quotes three of the very earliest observations of the obliquity to show that Drayson's formula does not hold good for long periods, which is hardly fair considering that for the first two the instruments then in use could not probably give a nearer approximation than Ptolemy's astrolabe of later date, which I have seen stated to be only correct within ten minutes. The telescope and the correction for refractions came long after all these observations. One would very much like to know how the odd three seconds of the Chinese calculation in 1100 B.C. were arrived at, even if any Vernier system were employed. The reviewer is more correct in saying that the figures require little comment than fair in stating the consequent utter breakdown of Drayson's formula as applied to obliquity. But surely we have proof within proof, and a squaring of the proof, in the fact that the discovery gave Drayson such clairvoyance that, using as a basis a prophesied obliquity for A.D. 2295, he could calculate to a nicety the obliquities for four hundred years back. I do not think the significance of this has been rightly understood. There is an almost equally cogent proof in the fact that the new curve entails a decreasing rate of the decrease in the obliquity. Observations for the last two thousand years provide this decreasing rate in full consonance with the curve.

The criticism which follows is more fair. Drayson in his writings, however, allows that some stars have proper motions of their own, but "a very great number of the so-called 'proper motions' of the fixed stars are due to the same cause as that which accounts for the glacial epoch of geology, viz., the movement of the Earth's axis in a manner which has not hitherto been correctly interpreted." If the spectrum shows that the majority has a proper motion, the explanation may prove to be that their enormous distances permit of such motions being practically negligible.

The other points connected with the climatal changes would cover too much ground for discussion here, but I do not subscribe to all that Drayson may have said about

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migration. I have now printed a pamphlet* in which some former gaps in the geological evidence have been filled up, with the result that there are no fewer than eleven independent sources of evidence to show the different phases of the glaciation cycle, in many cases with astonishing approximation, and I can confidently claim to have attained my object, namely, the proofs of a recent glacial period; and whereas in all respects they agree with Drayson's results, I am justified in believing that astronomers are wrong. I have lately become acquainted with a twelfth source of evidence, in that Dr. N. O. Holst, of Sweden, has computed from certain peat beds in Southern Sweden that glaciation came to an end six thousand nine hundred years ago, and began twenty-two thousand years ago—and this without any knowledge of Drayson. The geological position is so impregnable as regards the main features that geologists need no longer depend on the backing that an acknowledgment of Drayson's discovery by astronomers would give.

Galileo was scoffed at for upholding the statement regarding the phases of Venus on the Copernican theory, but fortunately lived to see them proved by his telescope.

The phases of the last glaciation are equally definite, and before long the world will wonder at the perversity with which a discovery of such importance has been persistently stifled.

Critics in astronomy demand that the secondary rotation should have some reasonable cause assigned to it. The retort suggests itself that the daily rotation should come first in the sequence of explanations.

Newton was also asked to explain this secondary movement, and he did so according to his lights. At the same time it seems somewhat of a departure from one of the corollaries of his own laws of motion, according to which the influence exerted by one body on another may be supposed to act at their respective centres, unaffected by equatorial protuberances. Had Newton known that the obliquity was decreasing, and that the earth's centre of gravity was probably eccentric, he would never have sanctioned the error of the pole of ecliptic centre.

With an eccentric centre of gravity, and with the known behaviour of the gyroscope of which the second rotation is due generally to air resistance, we have an analogy for the earth, under the influence of the tides, complete enough to give the precession movement of the earth a new basis for investigation.

To sum up the position, I think it has been shown that the "inconsistencies, contradictions, and grotesque hypotheses" surrounding the second rotation exist chiefly in a prejudiced imagination. I might say the boot was on the other leg, since the reviewer and his supporters pin their faith on an assumption of Newton's based on information manifestly not up to date; and to support this assumption they depend on a movement of the ecliptic plane, about which astronomers cannot even approximately agree, and which geometricians assert to be, on that assumption, impossible. The despised Drayson encounters none of these difficulties. His path is smooth, and nothing is wanting to prove his case except due investigation, which his discovery has never yet received.

In the reprint from the *Candid Quarterly*, previously alluded to, after enumerating the various hypotheses for the cause of an ice-age, and showing how the term "pre-glacial" may now mean anything from twenty-five thousand to five hundred thousand years ago, I submit Drayson to the sober judgment of my readers as follows:—

"If, after a century of endeavour, science has brought us no nearer to a solution than is indicated by this chaos of opinion, surely a solution of the difficulty, supported by twelve independent outstanding facts, as well as by a discovery in astronomy which *foretold* and now explains each one, is worthy at least of being adopted as a working hypothesis."

Those who have accepted, as I have, the results arrived at by Drayson are awaiting, not attacks such as that of your correspondent, but guidance. Let some true astronomer, mathematician, or other man of science explain to us the ***admitted fact*** that the obliquity of the earth's axis is decreasing by 46″ each century. Will that decrease follow the curve which Drayson has predicted; or is there some other explanation which will change or terminate that decrease, and at the same time fit all the phenomena and facts equally well?

There is nothing strained or unnatural about Drayson's reasoning, and it provides the cosmical cause for which geologists have in vain sought. If the truth of his theory as opposed to the astronomical one is to be gauged by the ratio of the number of phenomena explained to the number of assumptions made, there can be but one result. Many years ago Sir Robert Ball, when asked why Drayson could not be accepted, replied, "Because it would be too upsetting to the framework of astronomy," or words to that effect. If truth is in this direction, a readjustment of this question will be well worth the sacrifice of a few unfounded assumptions, however distasteful the process may be.

R. A. MARRIOTT.

Lewes.

THE WAR AND AGRICULTURE.

By HENRY GARNETT, F.C.S.

THAT the shortage of labour consequent on the drain on labour through enlistment is having a serious effect on agriculture in this country is becoming more and more evident as the seasons go by. Apart from the actual loss of crops which is prophesied through there being so few hands to gather them, a casual glance at the standing crops is sufficient to show the ravages caused by that great enemy of the farmer—weeds. "A stitch in time saves nine," and a careful weeding early in the season will prevent the ill weeds growing apace, and choking the crops among which they appear.

The accompanying illustrations tell their own story. They have been taken near Manchester, on the Cheshire side. The chief offender among the weeds is the common charlock, or wild mustard, known under its scientific name, *Brassica sinapis*. The photographs were taken on the same day, and in normal times might have been labelled "Good and Bad Husbandry," but in these days the fault does not all lie with the farmer, as he has been unable to get the needful labour to do the weeding. Figure 210 shows a field of oats with scarcely a weed in it: it belongs to a small (and careful) farmer, who has personally seen to the weeding. Hardly a single weed is visible; the oats are thick and vigorous. Figure 211 shows a field which is a blaze of golden yellow, aesthetically a lovely sight, but the crop of oats is stunted and poor. More striking examples might have been chosen. In one field inspected it was impossible to gather what the original crop had been! It was charlock, charlock everywhere. In many cases it is doubtful whether the fields of corn will pay the cost of reaping. It is only fair to add that the continued drought has favoured the growth of the weeds, which penetrate deep with their long roots, and the ground is so hard that weeding has become impossible. Worst of all, the charlock and other weeds will soon be seeding, and providing a plentiful crop to "foul" the land next year.

* *The Glacial Epoch Explained.* Messrs. Baxter, Lewes. Price 1/1 post free.

FIGURE 210. A field of Oats without Weeds.

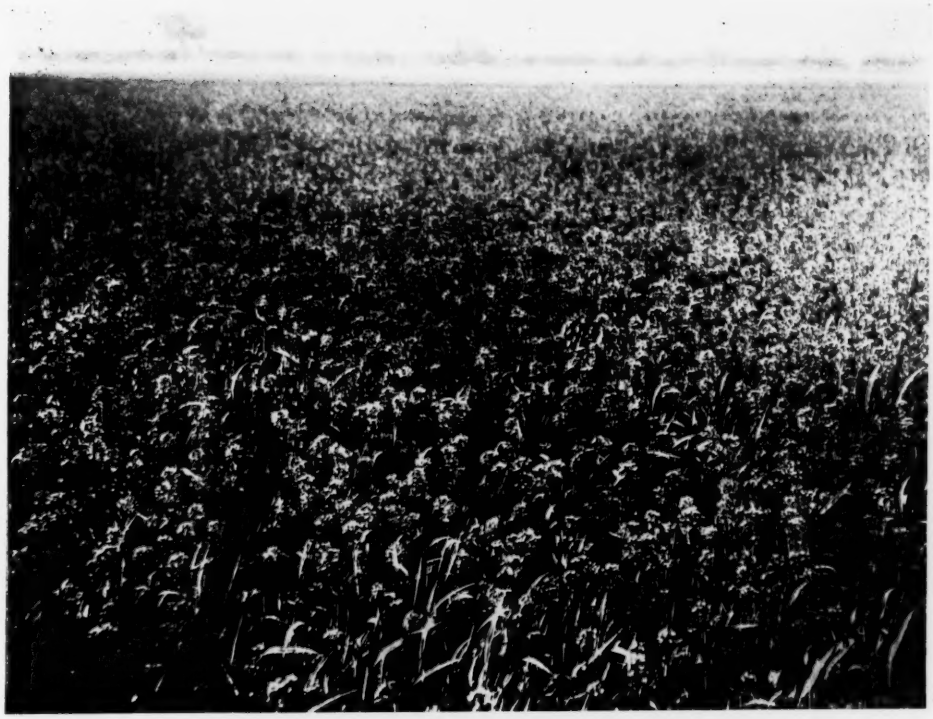
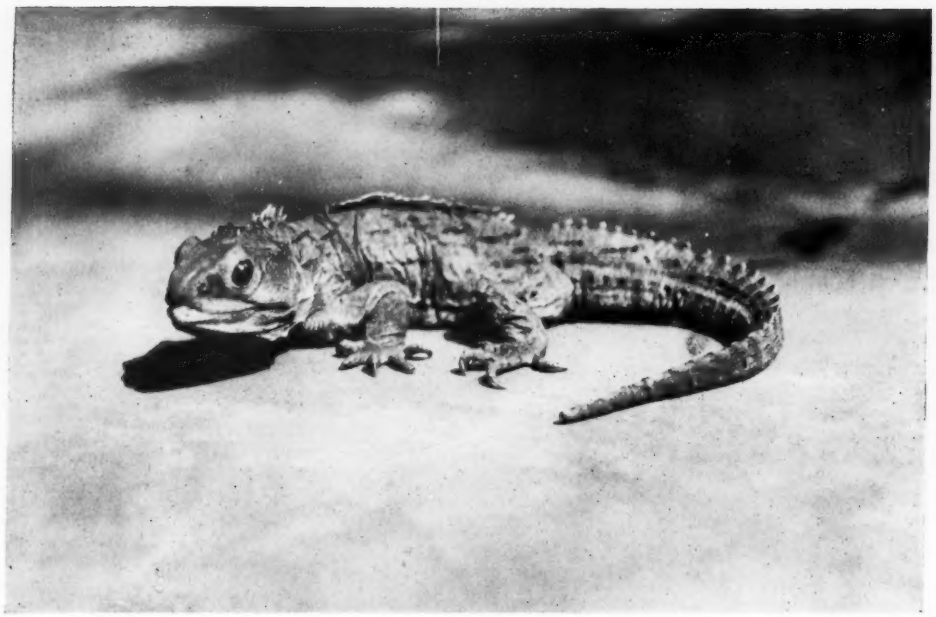


FIGURE 211. A field of Oats choked with Charlock.



From a photograph by *W. S. Berridge, F.Z.S.*

FIGURE 212. The Tuatara Lizard (*Sphenodon punctatus*).

FIGURE 213. Photograph showing the Japanese Maidenhair Tree (*Ginkgo biloba*), taken in the court of one of the Hongwanji temples in Kyoto.

(See page 236.)

NEW ZEALAND'S TUATARA: THE MOST ANCIENT REPTILE ON EARTH.

By R. W. REID, Bay of Plenty, New Zealand.

NEW ZEALAND possesses the most ancient living reptile. This is the tuatara, which is popularly described as a lizard-like creature. It is the sole surviving representative of the order Rhynchocephalia, now everywhere extinct, save in New Zealand. Its nearest ally is found as a fossil in the Jurassic rocks of Germany, so that no one may question the creature's pedigree and long line of descent. What it precisely is no one can very well say. Scientific men call it the *Sphenodon punctatus*; and a specimen is shown in Figure 212. Dr. Benham, F.R.S., Professor of Biology, and Curator of the Otago University Museum, describes it as a surviving fossil. In order to find anything like it structurally, he says, we must go back to very early geological times. It is of immense interest to naturalists, for the reason that it combines in many respects peculiarities of both the crocodiles and the turtles. In other lands, it would appear, the old-world tuataras came in a much greater degree under those mysterious forces which we term the laws of evolution, and one section branched off into turtles, while another section underwent so many changes that its members became crocodiles. The turtles and the crocodiles are now far apart in the world of living things; but once upon a time there were neither, only the tuataras. Then the creatures were supplied with three eyes, a fact which may help to account for their apparent placid indifference to neighbours and surroundings. For they could repose, not very gracefully, on a sunny rock, and survey the world on both sides of them, and above them, without turning their head or straining their neck to discover what aspect the sky wears.

Captain James Cook, the great navigator, must bear part of the blame for the slaying of the hapless tuataras. No doubt at one time the creatures were numerous on the New Zealand mainland; at the time, that is, when the lordly moa—a wingless bird which stood about twelve feet high—strode majestically through the scrub and the bush of Maoriland. But Captain Cook presented the Maoris with pigs wherewith to vary their larder, and the pigs seem to have begun the killing off of the tuataras. The "Captain Cooks"—big, black, long-snouted pigs, which thrive to-day in the New Zealand bush—caught the creatures easily on the surface of the ground, and almost as easily rooted them out of the burrows they occupied. Then came the white man, with his diverse following of cats, stoats, and weasels, and the poor tuatara's days on the mainland were numbered. Fortunately, the coast line of New Zealand has in places something like a string of adjacent islands, and upon these the tuataras had found a home. On these islands and islets at the present time, and probably on these alone, are the tuataras.

Last year the Dominion Minister of Internal Affairs adopted certain measures with the view of protecting the ancient reptiles. On many of the islands lighthouses are erected, and the keepers of these were, in a sense, appointed protectors of the tuataras. Those officials recently sent to the Minister reports concerning the number of tuataras in their proximity, the chief dangers to which they are exposed, and as to whether their numbers are increasing or dwindling away. Many of those documents are of considerable value, and none of them is without interest. Combined they show that on something like a score of islands, here and there off the coast, the tuataras are living, and, on most of the islands, holding their own against their enemies. On a few islands, where formerly they were said to be numerous, the numbers have not apparently been maintained; but on several islands come reports of actual increases. At one time, not only the eggs, but also the tuataras themselves were sold, and sent out of the country This traffic has now been rendered illegal, and fines may result from attempting to remove the ancients from their island homes. On these islands, however, the kingfisher seems to have developed a taste for tuatara. Hawks also prey upon them; but seemingly to no great extent. The lighthouse-keeper on the Brothers, for example, fears that the hawks get a few. "I have seen the hawks on Stephen's Island," this official writes, "swoop down upon the tuataras, carry them aloft to a good height, and drop them on the rocks, killing them. Then the hawks ate them." Another official, writing on September 30th last year, states: "The tuatara is now over its winter sleep, and can be seen basking in the sun on various parts of the island." From these reports the information is gleaned that the female tuatara deposits her eggs in a hole in the ground, packs damp earth and sand around them, blocks up the entrance, and there her maternity duties come to an end. Time and the heat of the ground do the rest; and in from ten to twelve months the young make their appearance. When the tuataras emerge from their place of birth their mouths remain for some days as if hermetically sealed. The tuataras never venture very far away from their homes, though

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on foggy nights, for some reason not explained, they may be found occupied in a fairly extensive tour away from their own particular burrows. They live on flies, spiders, and the like, and display remarkable dexterity in effecting captures. Their length, when full-grown, is from twenty to twenty-five inches, and the young are seldom found less then six inches long. Their colour varies with age—usually it is dark yellow. The Maoris are not in love with the tuatara; and, in all probability, never were. Nearly ten years ago a gentleman living near Wellington discovered a tuatara on his farm on the mainland, and the occurrence was so uncommon that he announced it in the local newspapers. He placed the captive in a box at first, and invited the Maoris near to call and make its acquaintance. All declined, and indicated that they greatly dreaded the harmless and forlorn tuatara.

CORRESPONDENCE.

THE JAPANESE MAIDENHAIR TREE.

To the Editors of " KNOWLEDGE."

SIRS,—Having noticed two letters in your paper on the subject of the Japanese maidenhair tree (*Ginkgo biloba*), I think you may care to reproduce the enclosed photograph taken in the court of one of the Hongwanji temples in Kyoto (see Figure 213 on page 234).

These trees are commonly grown near temples in Japan, as there is a superstition that in the event of fire they will squirt water on the flames.

The photograph illustrates the great care which the Japanese bestow on their trees, supporting all the more horizontal branches on poles for fear of breakage.

Probably the most famous (historically) and largest maidenhair tree in Japan is that in the court of the temple of the God of War (Hachiman) at Kamakura. This tree I should estimate from memory to be twenty feet in circumference, and much taller proportionately than the one shown in my photograph.

J. GURNEY BARCLAY.

HIGH LEIGH,
HODDESDON.

SECONDARY SEXUAL CHARACTERS IN SEA-URCHINS.

To the Editors of " KNOWLEDGE."

SIRS,—In the Mediterranean region sea-urchins are considered a delicacy, but only the male is eatable. In Sumba the natives eat one with yellow, pink, and bluish spines (I will not answer for the exact shades); in New Zealand the Maoris eat the commonest sea-urchin there, but cooked. The only occasion on which it was tried raw proved it to be, in that condition at least, a violent emetic. The large common purple-black echinus with very long, almost hair-like spines and rows of azure eyes, so common on the tropical coral reefs of Northern Australia, is innocuous, and as good eating as the Mediterranean species, but the English colonists have not learnt to appreciate it. Our own large and beautiful, almost spherical, sea-urchins, so common on the rocks of Redcar, Cleveland, are eatable cooked, and probably also raw. Whether tropical sea-urchins have a different form, corresponding with their sex, I cannot say, but in the Mediterranean ones the difference is so marked as to be sensible to the touch.

The spines of the female are longer, coarser, and thicker than those of the male, and the whole echinus is flatter. The colour is invariably jet-black, with the exception of the skin round the mouth. This is of a dirty-green colour, and the mouth is concave. The males are of different shades from purple-black to olive-green, purple, reddish brown, or shot with purple. The spines are shorter and more finely pointed. The skin about the mouth is convex, and generally russet, and the whole echinus more spherical than the female. What is the explanation of these facts? Although so marked, they can hardly be due to sexual selection. And do the sexes also differ in the tropical species?

W. W. STRICKLAND, B.A.

SESTRI LEVANTI, LIGURIA
ITALIA.

BRIGHT METEOR.

To the Editors of " KNOWLEDGE."

SIRS,—On July 5th, at about 8.25 p.m., a very bright meteor was observed moving rapidly. It came round the side of the house, from the south-west, at about 45° from the zenith. Just before disappearing, at about 55° from the zenith and a little east of south-east, it broke into two (or more) fragments. A hissing sound was heard, followed by an explosion like that of a distant gun. Although not full daylight, the evening was fine and clear.

A. B. KNAGGS.

BISHOP'S SUTTON.

THE AUGUST METEORS.

By W. F. DENNING, F.R.A.S.

CONSIDERED in its various aspects, the shower, formed by the Perseids of August, is undoubtedly the best meteoric display of the year. Occasionally during the last century the exhibitions of Leonids or Andromedids in November quite eclipsed the summer Perseids, but they were exceptional spectacles. As a general rule, there is nothing in the round of the year's meteoric phenomena to match the Perseids.

As sure as the anniversary of St. Lawrence returns (August 10th), so sure do these meteors manifest themselves in very attractive lineaments upon the firmament. It is true that the visible character of the picture is subject to some annual variations. Sometimes there is moonlight; at other periods much cloudy weather prevails; at others, again, the region of the stream traversed by the Earth may be a little less rich than usual; and a fourth possible reason is found in the fact that the best phase of the event may return during the daytime, and cannot be witnessed.

But, whatever the interfering circumstances may be, something of the shower can be recognised every year, for it has the longest duration of all the known displays. It is true that it is rather feebly visible except on about August 10th to 13th; but a few of its meteors may be recognised from the opening nights of July to the fourth week in August.

Coming as it does just in the most genial time of the year, it can be watched under auspicious surroundings and with a frequently favourable sky. On the other hand, the autumn meteors are often obliterated in fogs and clouds; and, in any case, the chill nights of November offer a poor and often uncomfortable period for astronomical work in the open.

This year the richest phase of the Perseids will return with the Moon invisible, and the shower should be favourably displayed if the nights of the second week in August be

pretty clear. Formerly the maximum occurred on August 10th, but the date is not a constant one, owing to several conditions, and we must now expect the best exhibition on August 11th or 12th. St. Lawrence's Day is no longer the gala time for meteoric wonders: we have to watch for them a night or two later, though there are still some meteors to be seen on the ever-memorable date of August 10th.

The Perseids are directed from a radiant constantly above the horizon as seen from England, and its general position is in the north-eastern sky on the nights of August. The flights are very swift, and streaks are projected along the trajectories for short intervals of time. In regard to very brilliant Perseids, however, the luminous after-glows will sometimes remain for five or ten minutes.

The history of this system dates back to A.D. 802, and there appears to be some indication of a periodic time of one hundred and five to one hundred and six years; but it seems rather an annual display of moderate strength than a periodical storm of great intensity. Comet III, 1862, presents a suggestive similarity of orbit, and the identity of the cometic and meteoric systems is highly probable, if it cannot be said to be actually demonstrated by evidence.

The shower has a moving radiant, the successive positions being about as under and consistent with a progressive daily displacement of 1° to east-north-east:—

		α °	δ °				α °	δ °
Aug.	8	42	+57	...	Aug.	14	50	+58
,,	9	43	+57	...	,,	15	51	+58
,,	10	44	+57	...	,,	16	53	+58
,,	11	45	+57	...	,,	17	54	+58
,,	12	47	+57	...	,,	18	56	+58
,,	13	48	+57	...	,,	19	57	+58

The heights of the meteors are from about eighty to fifty miles, and their velocities, as observed, thirty-nine miles per second.

Though the shower has been recorded back more than eleven centuries, it was only during the nineteenth century that it enlisted the attention it deserved. Old-time watchers of the heavens failed to realise the importance of obtaining notes of the details of such phenomena as were presented to them. They seemed content to record the dates, and possibly a brief description as to the nature of the events, but beyond that we usually have to search in vain for any data calculated to elucidate the occurrences.

Schiaparelli, about half a century ago, proved the physical association of comets and meteors, and indicated the derivative comet of the Perseids. And every year the meteors are observed, though not with the widespread interest or with the invariable care and accuracy which their investigation essentially requires.

Thus we find ourselves still possessing a palpably imperfect knowledge of this prominent meteor shower. We

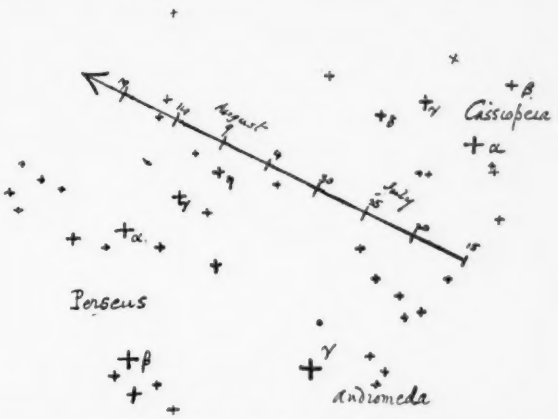

FIGURE 214. Perseid radiant from July 15th to August 19th.

have gained a clear insight, it is true, into its principal attributes, but there are several important features demanding renewed enquiry. To what extent is the radiant diffused? When does the shower really begin and end? What are the character and extent of its annual variations? What is its periodic time of maxima?

To the solution of these and other problems the future observer may apply himself to advantage; and the prospect of further enriching our knowledge in this field is really a good one to a thoroughly capable observer. The work requires patience, a good eye, a discriminating judgment, and a love for the subject. With the combination of these qualities success must come. And this field of work is alluring, and its objects of great and varied beauty, if they are transient and uncertain in their appearances.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

MOUNT WILSON SOLAR OBSERVATORY.—Some observers have doubted whether the shifts of lines in solar spectroscopy are due to motion in the line of sight, suggesting that they are rather due to anomalous refraction in the solar atmosphere. Mr. Charles E. St. John makes a critical examination of this suggestion, applying it to the radial motions in the penumbrae of sunspots. The ordinary theory gives a reasonable explanation of the observed phenomena. According to this, the lower levels are moving outwards from the spot, while the high-level chromospheric spectrum (calcium, hydrogen, sodium, magnesium) indicates an upper counter-current setting inwards. Such counter-currents accord well with physical laws. It is shown, on the other hand, that the anomalous refraction theory would require a very artificial and improbable density distribution to explain the facts. The theory is therefore dismissed.

Professor Hale and Mr. H. D. Babcock have examined the strength of the electric field in the solar atmosphere by means of the splitting effect that such a field produces on spectral lines. They give one hundred volts per centimetre as an approximate value of the field strength in the region examined. This is much less than other observers had announced, but the region was an undisturbed one, and they suggest that the strength of field may be much greater in regions of disturbance.

The flash spectrum, which used to be obtainable only at eclipses, is now studied in full sunshine at Mount Wilson. Comparison with the eclipse results shows that the spectrum can be traced to a lower level in the solar atmosphere than during totality. Accordingly, while the eclipse spectrum shows practically all the lines as bright, many of them appear as dark lines with bright fringes in the Mount Wilson photographs. The latter photographs show some interesting differences between the flash spectrum and the ordinary solar spectrum. It is concluded that the heavy elements, such as iron, lie low in the solar atmosphere, and it is expected that further study will explain the other peculiarities of the spectrum.

Besides the solar work, the sixty-inch reflector at Mount Wilson is used to obtain radial velocities of fainter stars. The results are discussed by Professors J. C. Kapteyn and W. S. Adams. They find that the radial velocities, even of the very distant stars, support the Two Stream hypothesis.

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Professor Eddington has reached a similar conclusion. They find that the individual star-motions show a velocity distribution different from that given by Maxwell's law. It appears that the stars of great absolute luminosity move more slowly than the fainter ones, the difference amounting to about 1·1 kilometres per second per unit of absolute magnitude. The use of Hertzsprung's results for the very luminous stars of the δ Cephei type raises the value to 1·5 kilometres per magnitude.

MARS.—Another Mars season will commence soon, and Professor W. H. Pickering gives some useful hints to observers in *Popular Astronomy* for May. He advises a scale of one-eighth of an inch to one second of arc. In making a drawing, begin with the polar cap; then the centre of the disc; then the limb detail; then the filling in of minuter detail. The principal outlines should be drawn fairly rapidly, to avoid the change produced by rotation. He explains a scale of seeing, and says it is of little use observing Mars when the seeing is less than 6 (10 being perfect seeing), or the altitude less than 30°. The width of fine lines on the disc should be estimated by a scale of lines of various widths attached to the outside of the telescope tube. It is advisable to exaggerate differences in the shadings of the Maria, and so on. The use of colours is recommended, and useful hints are given of the best method of lighting the drawing. Tungsten lamps, with pale blue shades, are recommended.

On September 11th the diameter of Mars will be 6″, the northern polar cap being then near its maximum size. Opposition will be on February 9th.

A STUDY OF ECLIPSING BINARIES.—Mr. Harlow Shapley, of Princeton University Observatory, N.J., has published an interesting volume on these stars, forming Number 3 of the Observatory contributions. The early work on Algol took no account of the important factor of the variation of luminosity of the discs of the two stars, due to atmospheric absorption. Further, it was generally assumed that the *comes* was quite dark. Mr. Joel Stebbins disproved this for the Algol *comes* by detecting a secondary minimum when it passed behind the bright star. It is likely that the same is true in most cases. The author says, "In all but five or six cases we have positive evidence that the fainter star is self-luminous." Polar flattening is another possibility, but it is difficult to deduce this from the light-curves. A few well-known stars, notably Algol, have their light-curves so carefully mapped that it is possible to detect a variation in the luminosity of the small star, due, it is supposed, to the side of it turned towards the primary being hotter and more luminous than the other side. The author has collected the observations of over thirty observers made by the best modern methods. A surprising amount of information is extracted from these, relating to the shapes of the stars and of their orbits, and the degree of limb-darkening. Line-of-sight velocities are used, wherever available, to supplement the results from the light-curves. He finds β Lyrae a very puzzling system. Strange to say, though it is such a bright and well-known star, little photometric work of the necessary accuracy has been done upon it. He suggests as likely that it is two masses in contact, on the verge of division: a small, bright star and an immense, fainter companion.

The rule of the fainter companion being the larger is stated to hold in four-fifths of the systems discussed. The average density of the small, bright components is one-eleventh of the Sun; of the large, faint components, about one-thirtieth.

Theoretical parallaxes are derived from the data, the surface brightness being assumed from the spectral type. Since the size can be deduced from the light-curve, the distance can be calculated. Most of the stars appear to be very distant.

The four nearest ones are:—

	Parallax.	Distance.
	″	
β Aurigae	0·030 ...	105 L.Y.
Algol	0·026 ...	120 L.Y.
W Ursae Majoris ...	0·020 ...	163 L.Y.
R Canis Majoris ...	0·018 ...	180 L.Y.

These are the only four out of the ninety discussed that seem to lie near enough for their parallax to be determined by direct measures.

The most distant of the stars discussed appears to be W Crucis. Its hypothetical parallax corresponds to a distance of 17,000 L.Y.

In view of the great distance of the majority of the binaries, it is not surprising that they show a marked condensation towards the Galactic plane. Only thirteen of the ninety binaries have a Galactic latitude exceeding 30°. The distances are estimated on the assumption that space is perfectly transparent; if light is lost in transmission, the stars would be correspondingly nearer. In any case, the results support the conclusion which has been reached in many other ways, that the diameter of our star system is measured by thousands of light-years.

Mr. Shapley notes some useful researches that would increase our knowledge of these eclipsing binaries.

(1) A more exhaustive examination for secondary minima (faint star eclipsed by bright). These need refined photometric methods.
(2) Special examination of R Canis Majoris, which has an unexplained hump on its light-curve.
(3) Work on the red eclipsing stars would give valuable information about their density.
(4) Stars whose period varies should be kept under constant observation.

OBITUARY: MR. G. F. CHAMBERS.—Mr. Chambers's name must be familiar to most of our astronomical readers. His portrait appeared in "KNOWLEDGE" last February (page 45). His "Handbook of Astronomy," which he wrote at the age of twenty, is a widely known and useful work, which has run through many editions. The "Story of the Comets," which was appropriately brought out at the time of the apparition of Halley's Comet, had also a rapid sale. He interested himself in the numerous eclipse expeditions organised by the British Astronomical Association, and greatly facilitated them by the thoroughness of his enquiries into the local conditions and the travelling arrangements. Unhappily his arrangements for August, 1914, were frustrated by the war. But, with his sanguine disposition, he went on to make plans for the coming totality of February, 1916, which are now unlikely to be realised. He was a regular attendant and frequent speaker at the meetings of the Association, and was frequently an active member of its Council.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

SULPHUR BACTERIA.—Three interesting papers have recently been published on the remarkable group of micro-organisms called "sulphur bacteria," which play an important part in the circulation of sulphur in nature, comparable with that of the various nitrogen bacteria, which bring about the more complex nitrogen cycle in soil and water. The sulphur bacteria are capable of oxidising sulphur or one of its unoxidised compounds, producing in some cases sulphur and in others sulphuric acid. Two series are distinguished: (1) Those which structurally resemble ordinary bacteria and do not store up sulphur internally, *e.g.*, the Thiobacilli, which oxidise thiosulphates to sulphur or sulphuric acid, and so obtain energy which they expend on the reduction of carbon dioxide, thus being enabled to make their own food, as green plants do, though in a different manner; (2) a number of forms which show

remarkable structural peculiarities, and which oxidise sulphuretted hydrogen to sulphuric acid, sulphur being first formed and stored within the cells in globules, which are then further oxidised. There are two classes of sulphur-storing bacteria: Colourless forms, of which two (*Beggiatoa* and *Thiothrix*) have been found by Keil (1912) to be capable of utilising carbon dioxide, and the so-called purple sulphur bacteria, which have a red pigment.

These pigmented forms have recently been investigated again by Skene (*New Phytologist*, 1914). They grow in stagnant water; and, though not very common, occur in such masses as to colour the water or mud bright red; hence they were early discovered and described; but it was not until 1888 that Winogradsky recognised the significance of the sulphur inclusions in these bacteria, and found that they could not develop in the absence of sulphuretted hydrogen. Skene has reinvestigated some of these bacteria, and the following are his chief results. All attempts to obtain pure cultures of purple sulphur bacteria failed; in mixed cultures *Amoebobacter*, the chief form investigated, thrives best in a mineral solution containing ammonium sulphate as a source of nitrogen, and chalk as a neutralising agent. All the organic sources of nitrogen and carbon tried proved to be without favourable influence on the growth of the bacteria, and, indeed, usually tended to inhibit development: growth only took place in the presence of sulphuretted hydrogen, which could not be replaced by other sulphur compounds; growth only took place in light, red light being more effective than blue. These bacteria require free oxygen, which is probably supplied in nature by associated green organisms.

West and Griffiths (*Annals of Botany*, Volume XXVII) have described a new genus of sulphur bacteria, found in the mud of freshwater pools, to which they give the name *Hillhousia*. Nadson (see below) considers that these forms are simply species of the already known genus *Achromatium*; but, whereas *Achromatium* is said to store up lime in the form of oxalate and to contain no sulphur, *Hillhousia* contains carbonate of lime in the cells, and also reddish grains of sulphur. The physiology of these remarkable "lime-sulphur" bacteria has not been worked out in detail, but they are easily affected by slight changes in their environment; and, in order to remain in a healthy condition, they require a sufficiency of lime-salts, sulphuretted hydrogen, and oxygen. If fresh water is allowed to run through a collection, the organisms lose their sulphur within forty-eight hours, but the sulphur grains reäppear if the mud is left undisturbed so that sulphuretted hydrogen can accumulate. The addition of this gas to organisms removed from the mud and placed in fresh water also causes the sulphur grains to reäppear, provided the water has been aërated; if there is not sufficient oxygen, the organisms exude their globules of calcium carbonate, leaving a double line of crystals of calcite as they move slowly about, and subsequently death ensues.

Nadson (*Bull. Jard. imp. bot. Petrograd*, Volume XIII) has published an account of his observations on sulphur bacteria in brackish water on the coast of the Gulf of Finland, describing two new species, *Thiophysa macrophysa* and *Achromatium gigas*, the cells of which were found to contain, in addition to sulphur, bodies ("oxalites") which are probably oxalate of lime. On diminishing the oxygen supply more sulphur accumulated in the cell, and the number and size of the "oxalite" particles decreased, while, on increasing the aëration of the water or mud, the sulphur diminished and the "oxalite" increased. Nadson also discovered a new genus of sulphur bacteria, *Thiosphaerella amylifera*, which contained in its cells large amounts of a starch-like substance.

THE PRIMITIVENESS OF WOODY FLOWERING PLANTS.—During recent years various lines of investigation have been leading to the view that herbaceous flowering plants are of comparatively recent development, and have arisen from woody forms, which were the primitive types. Sinnot and Bailey (*Ann. Bot.*, Volume XXVIII) have contributed a critical discussion of the relative antiquity of herbs and woody plants, and set out the evidence for the primitiveness of woody plants under four main headings. (1) Palaeobotanical evidence: living herbaceous Vascular Cryptogams are undoubtedly descended from woody types, all known Gymnosperms are woody, and most of the earliest-known angiosperms were also woody. (2) Anatomical evidence: in Vascular Cryptogams with secondary growth the cambium appeared as a uniform and continuous layer, and irregularity in the cambium of Conifers and Angiosperms is a recent phenomenon, due to the close attachment of primary to secondary wood, owing to the disappearance of the centripetal wood, the parenchyma produced by the interfascicular cambium being thus of recent origin. The herbaceous type of stem structure is derived by reduction in cambial activity and increase in width of the medullary rays from the woody type, and the herbaceous stem is essentially like the first annual ring of its woody ancestors. (3) Phylogenetic evidence. That primitive Angiosperms were probably arborescent is clearly indicated in families where both woody and herbaceous species occur (*e.g.*, Umbelliferae, Leguminosae), for the former are obviously the primitive forms. Herbaceous species are absent in more than half the families of Dicotyledons, and the purely herbaceous families are clearly of recent origin; woody plants are much more common in the lower Dicotyledons (Archichlamydeae) than in the higher (Gamopetalae). (4) Phytogeographic evidence. The tropical climate resembles that of the time when Angiosperms first appeared, and an analysis of floras shows that woody plants prevail in the tropics and herbs in the temperate regions. The development of herbaceous forms in temperate, alpine, and arctic regions probably represents a response to progressive refrigeration during the course of the Tertiary period; the majority of herbs originated in the continental area of the north temperate zone, and thence invaded the Antipodes along the Himalayas, Andes, and African highlands. It has for a long time been recognised that herbaceous plants are better adapted to adverse conditions, and that, as compared with trees and shrubs, they are hardy, aggressive, and successful invaders.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

COLOURED GLASS OF THE MIDDLE AGES.—An interesting study of the mediaeval glass from the windows of Rheims Cathedral has been made by M. G. Chesneau (*Comptes Rend.*, 1915, CIX, No. 19). He finds that violet glass contains iron oxide and traces of copper and cobalt, in addition to manganese in the form of Mn_2O_3. The presence of these elements points to the use of impure pyrolusites in the manufacture of the glass. The blue glass contains the elements usually found in association in native arseniosulphide of cobalt. The absence of any nickel in the glass indicates that means had been discovered in the thirteenth century of excluding it from zaffre, and thus preventing the brown coloration produced by nickel. The green glass contains the mixed oxides of copper and iron, together with a small amount of cobalt and a large amount of manganese. The red glass appears to have been produced by means of a very thin layer of enamel, which was coloured with cuprous oxide.

THE GERMAN POISON GASES.—M. J. de Waal discusses the nature of the asphyxiating gases used by the Germans, in a recent issue of the Dutch paper, *Chem. Weekblad*, 1915, XII, 508. Although the general opinion is that chlorine has been used for the purpose, he considers that another gas or gases have also been used for the purpose. The colour attributed to the gases by many observers is more compatible with nitrogen peroxide than with chlorine, and the description of the pathological

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effects suggests nitrogen peroxide or nitrosyl chloride rather than chlorine.

With regard to the absorption of the gases, it is stated that ferric chloride has been found in the respirators. Suitable substances for the absorption of nitrogen peroxide would be alkaline solutions, while calcium cyanamide could also be used for the fixation of nitric acid:

$$CaCN_2+2H_2O+4HNO_3=Ca(NO_3)_2+CO_2+2(NH_4)NO_3$$

Other useful substances for the purpose include esters of alcohols, and in particular amyl acetate, and, to a less extent, butyl acetate, amyl valerianate, and amyl formate.

One part of chlorine will bleach from five thousand to ten thousand parts of flour, while the action of nitrosyl chloride is more than four hundred times as effective. If the poisonous action of the latter upon the human organism is proportional to its bleaching activity, we have an explanation of the particularly deadly character of asphyxiating gases that contain it.

VITALITY OF *BACILLUS COLI*.—Experiments have been made by Messrs. Ayres and Johnson (*Journ. Agric. Research*, 1915, III, 401) to ascertain to what extent the *Bacillus coli*, the typical micro-organism of sewage, can survive the pasteurisation of milk. Pure cultivations showed considerable variations in their thermal death-points when heated in milk for thirty minutes under conditions comparable with those usual in the pasteurising process. At 60° C. more than half the cultivations survived, at 62°·8 C. (the usual pasteurisation temperature) twelve out of one hundred and seventy-four cultures survived, while one was not entirely destroyed at 65·6° C. until the heating was repeated. If, therefore, milk were heated for thirty minutes at this latter temperature, few of the bacilli would survive; and it is suggested that the colon bacillus test might be used as a valuable proof of the effectiveness of the pasteurisation process.

VALUATION OF PIGMENTS BY COUNTING.—An ingenious adaptation of the physiological method of counting the corpuscles in blood to the valuation of pigments, and other chemical products, has been published by Dr. C. Kühn in the *Zeitschrift für angewandte Chemie* (March 16th, 1915). The finely powdered material is mechanically shaken for fifteen minutes with a measured quantity of a suitable medium, such as glycerine or an oil, until the mixture is homogeneous. A minute quantity (0·01 cubic centimetre) is now withdrawn by means of a micro-pipette, diluted to one cubic centimetre with the liquid, and again shaken for fifteen minutes. One drop of this dilute mixture is transferred to the object-glass of a Zeiss-Thoma chamber, as used for counting blood-corpuscles, and the number of particles counted under a magnification of five hundred and fifty diameters. Duplicate results should agree within about four per cent.

The method will show the degree of fineness of flour, of ground pigments, oil-paints, and chemical precipitates. For example, it showed that one gramme of heavy spar contains 4·5 milliards of particles. After regrinding, the number rose to twelve milliards; and after a third grinding to 18·4 milliards. A sample of lamp-black, with a specific gravity of 1·57, contained nine hundred and sixty milliards of particles per gramme. Hence an average particle was calculated to have a diameter of 1·08μ, and to contain twenty-six milliard molecules of carbon.

REPORT ON WHITE LEAD PAINTS.—The departmental committee appointed in 1911 to consider the danger attendant on the use of paints containing lead has now issued its report. It is recommended that the importation, use, or sale of any paint containing more than five per cent. of its weight of a soluble lead pigment should be prohibited, such prohibition not to come into force until three years after the issue of the report. Specified methods for determining the soluble lead compounds are outlined. While the paints used by artists and in certain branches of painting would have to be exempted from the five-per-cent. limitation, such exemptions would only be permitted under special regulations. The use and manufacture of zinc pigments, and of other substitutes for white lead, are discussed at length in the report. Finally, it is suggested that any legislation on the subject should also give powers to deal with linseed oil and other paint media the vapours of which may produce ill effects.

GEOGRAPHY.

By A. SCOTT, M.A., B.Sc.

CLASSIFICATION OF EURASIAN MOUNTAINS.—In the third volume of "Antlitz der Erde," published in 1901, Suess advanced the view that the Eurasian Mountains could be regarded as made up of three constituents, the primitive nucleus, the Altaids, and the marginal chains. The first of these includes the great mass of folded Palaeozoïc rocks which encloses the foundered area round Irkutsk, as well as several "subnuclei" farther west, and the Altai Mountains of Mongolia. The latter are not included in the Altaid zone, which is subdivided into three groups: the Western Group, due to Carboniferous folding, and including the Kuen-lun Mountains, the Pamirs, and the Caucasus; the Alpids, or posthumous Altaids, due to Kainozoic folding, and including the Alps, Apennines, and Carpathians; and the Eastern Zone, comprising the mountains of North-east and South-east Asia. The marginal chains comprise the mountains formed by recent folding, such as the mountains of Japan and the Himalayas, which are continued through the plateau of Iran to the Dinaric Alps. In a recent paper (*Geog. Journ.*, June, 1915) J. W. Gregory discusses the classification, and, while criticising certain particulars, maintains the general validity of Suess's doctrines. A geographical classification should depend mainly on the existing relief of the mountain systems, and one of the chief objections to Suess's classification is the undue importance given to the early geological history of the areas concerned. This tends not only to separate systems of similar origin, such as the Alps, the Himalayas, and so forth, but also to obscure the effect of similar geographical elements. There are also several drawbacks to Suess's correlation of Europe and Asia, which depends on the view that in Asia the foundering is central, and in Europe peripheral. Foundered areas occur round the east and south coasts of Asia, and also are found centrally in Europe. Apart from these objections, Suess's views seem valid, particularly with regard to the separation of the Himalaya from the mountains of North-east Asia.

THE INDO-GANGETIC TROUGH.—While there is general agreement regarding the existence of a deep trough beneath the great alluvial deposits of the Indus and the Ganges, there is considerable difference of opinion concerning the origin of this trough. Suess, applying his general hypothesis of the origin of "foredeeps," attributed it to horizontal compression, due to the southward advance of the Tibetan Mountains, a view adversely criticised by J. Geikie. Oldham ascribed it to a subsidence of the earth's crust, owing to the weight of the enormous thickness of overlying sediments. Burrard rejected these hypotheses in favour of the view that the foredeep arose through "the opening of the subcrust under tension." In the *Proceedings of the Royal Society* (A. 91) he reiterates this opinion, and advances several objections to Oldham's hypothesis. He argues, from the analogy of a floating iceberg, that if alluvium has depressed the subcrustal magma to a depth of twenty thousand feet, five thousand seven hundred feet should stand above sea-level; the actual height, however, is less than three hundred feet. (It seems to the present writer that this height of five thousand seven hundred feet should

be measured from the magma surface, and not from sea-level.) The Himalayan foredeep is very similar to the Tuscarora deep, which cannot have been formed by compression due to sediments; the former, moreover, also extends out to sea. Geodetic observations indicate a continuation of the trough along the base of the Sulaiman Mountains, where the alluvial deposits are insignificant, while they also suggest that the greatest depth of the trough is much farther south than the depression theory demands. Burrard's explanation is that under tensile strain the surface of the earth has cracked, and the crack partially filled with the products of denudation. As the subcrust moved northwards the Himalayas were vertically uplifted, as were also portions of the material which had sunk into the crack. The latter are now found as the Siwalik foot-hills.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

ORIGIN OF PILLOW STRUCTURE IN LAVAS.—Comment has frequently been made in this column on the curious structure known as pillow-lava, which is now known from many parts of the world. A lava with this structure exhibits the appearance of a great pile of small masses which have been variously compared to pillows, bolsters, sacks, and cushions. The pillow generally has a vesicular crust, and occasionally a skin of glass, whilst the interior may or may not be hollow. The pillows sometimes make an impression on their neighbours, as if they had been somewhat soft at the time of formation. The interspaces between the pillows are generally filled with a breccia cemented by various secondary minerals. In some districts the interspaces are filled with radiolarian cherts or other siliceous rocks. The masses are frequently elongated, like bolsters, and there is generally a pronounced parallelism of their longest axes. Lastly the pillows may be connected one with the other by short necks or along their sides.

The origin of this peculiar structure has been exhaustively considered by J. V. Lewis after a discussion of all known occurrences (*Bulletin of the American Geological Society*, December, 1914). He considers all previous theories of origin as unsatisfactory, and propounds a new one (" bulbous budding ") which certainly seems to meet most of the facts as at present known. The following is a *résumé* of the theory.

Pillow structure is only found in free-flowing basaltic lavas, which retain a high degree of liquidity through a long period of cooling, and develop a notable degree of viscosity within a limited range of temperature as they approach rigidity. In the declining stages of a lava-flow with these characters a crust forms on the surface, and the flow is continued only by the escape of liquid lava from innumerable cracks and fissures in this crust. Thus for one great flow may be substituted a multitude of small flows, each of which will form an elongated bulbous mass. A tough skin will form on the surface of each of these small flows, and the internal pressure of the lava will expand this skin until rupture occurs, with the formation of another small extrusion which quickly congeals into a new pillow. This process may be repeated so long as the supply of lava is continued in suitable amount and at favourable temperatures. The expansion of each pillow until it becomes rigid produces a pseudo-flow structure parallel to the outer surface, concentric arrangement of vesicles, and tangential arrangement of microlites and phenocrysts within the lava. The vesicular crust and glassy skin is due to the quick cooling of the pillows in contact with the atmosphere or with water.

This hypothesis of origin explains the internal characters of the pillows and their general parallelism with each other and with the direction of the flow of lava. Furthermore, the neck-like connection of one pillow with another may often still be recognised, although subsequent conditions tend to destroy the junctions, as they are points of weakness in the structure. The interspaces are filled with fragments spalled off from the pillows, or with fine mud and sand where the lava has flowed into soft sediment. Material may also be washed into the interspaces, and they afford space for the crystallisation of many secondary minerals such as zeolites. Hollow pillows may be developed by the cessation of the lava-flow, and the consequent draining of the bulbous masses. Lastly the process of pillow-formation here described has been directly observed in modern lavas, as in the crater of Kilauea, Hawaii, and on Savaii, in the Samoan Islands. All transitions may occur between typical pillow-structure, and the wrinkled, twisted, and ropy form known as " pahoehoe," which is so often seen in modern lavas.

BOX-STONES.—The box-stones are rounded pieces of sandstone found in a conglomeratic deposit at the base of the Red Crag, and, occasionally, also of the Coralline Crag of East Anglia. They owe their name to the fact that about ten per cent. of them are found to contain enclosed fossils, the characters of which point to the blocks being derived from an older Pliocene deposit now entirely lost by denudation. The palaeontology of these stones has been well studied, but no account has hitherto been given of their petrological characters. Mr. P. G. H. Boswell (*Geological Magazine*, June, 1915) has now studied them from this point of view, with the result of throwing much additional light on their source.

The box-stones consist of a brown sandstone, mainly composed of angular quartz grains in a dark matrix, which is extensively phosphatised. An analysed specimen gave no less than twenty per cent. of calcium phosphate, which is regarded as existing in the form of iron-stained phosphorite. An examination of the mineral constitution of the sandstone by electro-magnetic separation and by the use of heavy liquids, resulted in the detection of an interesting and characteristic suite of " heavy " minerals. The typical minerals are red garnet, andalusite, staurolite, epidote, muscovite, and kyanite, with subordinate amphibole and tourmaline. The ubiquitous zircons and rutile are less abundant in the box-stones than is usual in sandstones. This assemblage indicates clearly that the box-stones were derived from an area of metamorphic rocks adjacent to a crystalline massif, in which minerals of metamorphic origin, such as andalusite, staurolite, kyanite, tourmaline, epidote, and muscovite, were present in great abundance. The richness and variety of the suite, the angularity and large size of the grains, together with the absence of grading in size, suggest that the constituents had not travelled far. The nearest area answering the above description is found in the Ardennes, but in the meantime Mr. Boswell does not commit himself to any definite statement of the origin of the box-stone material. He reserves the result of an examination of the mineral constitution of the Tertiary deposits of Belgium and Northern France, which are interesting in connection with the source of the box-stone minerals, for a future paper.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE WEATHER OF AUGUST.—In August, the last month of summer, the mean temperature, upon the average, is less than that of July; but in some years the greatest heat is not attained till this month. The high temperature at night constitutes a peculiar feature of the period. By the middle of the month the soil becomes so much heated by the continuance of summer heat that, after a fall of rain, a rapid evaporation occurs from the surface, and the atmosphere, thus loaded with moisture, becomes oppressive. Westerly winds are the most prevalent, with but little variation.

August was a very hot month in the years 1842, 1857,

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1871, 1876, 1884, 1893, 1898, 1899, and 1911. It was very cold in the years 1844, 1845, 1848, 1860, 1885, 1891, and 1912.

The average mean temperature at Greenwich for August is 61°·6; in 1857 it was as high as 65°·7, while in 1845 it was as low as 57°·4. The average maximum temperature is 72°·7; the highest mean was 81°·1 in 1911, and the lowest 66°·7 in 1912. The average minimum temperature is 53°·0; the highest mean was 57°·0 in 1911, and the lowest 48°·5 in 1864. The absolute highest temperature was 100°·0 on the 9th in 1911, and the absolute lowest 38°·1 on the 27th in 1864. The temperature rose above 90° on three days in succession in 1876 and 1893.

The average rainfall for August is 2·33-in.; the greatest amount was 5·38-in. in 1878, and the least 0·07-in. in 1818. The heaviest fall in one day was 2·16-in. in 1843 on the 23rd. The average number of "rain days" (*i.e.*, on which 0·01-in. fell) is 12·9; the greatest number of days was twenty-nine in 1848, and the least five in 1864. The average number of thunderstorms is two.

The average amount of bright sunshine at the Kew Observatory, Richmond, is one hundred and ninety-one hours, or forty-three per cent. of the possible duration. The average barometric pressure in London for August is 29·972-in.; the highest mean was 30·181-in. in 1778, and the lowest mean was 29·731-in. in 1860.

METEOROLOGY OF THE SUN.—At the meeting of the Royal Meteorological Society on March 17th Dr. W. G. Duffield, of University College, Reading, gave a lecture on "The Meteorology of the Sun." He said that, in spite of the Sun's immense distance, we are able to examine the meteorological conditions upon the solar surface. The temperature and barometric pressure are discovered by utilising the information conveyed to us by the rays from the Sun, which, after analysis by a spectroscope, provide information with regard to these conditions. The Sun's rotation is revealed by watching the motion of sunspots across the Sun's surfaces: the equatorial regions go round faster than those nearer the poles. The heavier elements in the Sun are in lower parts of the solar atmosphere than the lighter ones.

The distribution of an element upon the Sun may be examined by means of a spectro-heliograph, and the resultant photographs are maps of the Sun showing continents and islands of luminous calcium, hydrogen, and iron vapour.

Sunspots are shown to resemble cyclonic distributions upon Earth; a section of the Sun's atmosphere through a spot illustrates the motion of the vapour in a spot. There is no close resemblance between the general circulation of the Sun and that of our atmosphere. There is evidence of periodic surges in solar atmosphere extending over a period of eleven years. Thunderstorms probably occur in the Sun upon a scale immense compared with those in the Earth's atmosphere: their influence upon the solar atmosphere is discussed.

The discovery by Abbot that the Sun is variable opens up the prospect of further discoveries in connection with solar and terrestrial phenomena, the most important practical problem in the region of physics or meteorology. It is the hope of astronomers that the Earth will be completely girdled by observatories which will take part in the international scheme of cooperation in solar research. The promise of such observatories in Australia and New Zealand is welcomed by all interested in the development of solar and terrestrial meteorology.

MANCHESTER FOGS.—Mr. W. C. Jenkins has recently made a comparison of the number of days on which fog has prevailed in Manchester during the ten years 1904–13, and he finds that the number of days affected by this phenomenon has increased during the latter years by at least thirty per cent. as compared with the earlier years in question. By making a distinction between "foggy" and "gloomy" days, Mr. Jenkins shows that there is an increase of gloomy days during the summer half-year, the number during the winter months remaining fairly constant. The annual total number of days on which fog and gloom prevail is steadily increasing; the most marked advance is in the number of days affected by gloom, the increase being one hundred per cent. Gloom prevails on days of very little wind. The smoke cloud accumulates locally during the hours when house and office fires are being lighted, and before they are burning brightly. The greater number of glooms occur about 10.30 a.m.

As a further confirmation of the increase in the smokiness of the local atmosphere, Mr. Jenkins made some comparisons of the values of sunlight at two points on and about one hundred feet above the ground. These showed a loss by various methods of about ten per cent.

THE SUMMER OF 1912 IN AUSTRALIA.—From *The Australian Monthly Weather Report* for 1912 (the early numbers of which have only recently come to hand) it appears that the summer weather in the Commonwealth was of a most abnormal character. The outstanding feature of February was the great heat-wave over the whole of the Commonwealth (except the north-west, where the month was cooler than usual). Over Western Australia the heat was especially severe and continuous, and at nearly all the inland stations of that State the mean temperature was the highest for February on record. In South Australia, on the coast, and in the Upper North there has only been one warmer February in the past twenty-one to twenty-four years, and in Southern Queensland it was probably the hottest February since 1889. Maximum temperatures of 110° or over occurred on twenty-two days at various stations in the Commonwealth, the highest being 114° at Winning Pool, Western Australia, on the 28th.

In March two "willy willies" (tropical cyclones) occurred on the north-west coast within a fortnight—one on the 6th and the more severe of the two on the 21st. This interval of a fortnight is the shortest recorded for the last forty years, as in no other case have two "willy willies" been reported in the same month.

MICROSCOPY.

By F.R.M.S.

INSECTS' EGGS.—Insects' eggs elevated on slender stalks are sometimes found at this time of year on the leaves of plants in our gardens, and are not infrequently mistaken for mosses by those who find them; indeed, it is not an uncommon thing for them to be sent to botanists for determination, although they are really only the eggs of the beautiful lace-wing fly, *Chrysopa perla*. Some time ago a friend in South Africa sent me some minute objects which he had found on a twig, thinking they might possibly be of microscopical interest. He regarded them as vegetable growths, and, incidentally, asked for their identification. On placing them under the microscope I found them to be the stalked eggs of an insect, somewhat similar to those of our *Chrysopa*, but of very much smaller size, and with shorter stalks in proportion. They were iridescent, pearly white in colour, and of elongated elliptical shape, the major axis of which was about one-fiftieth of an inch: each was covered at the free end with a convex operculum, bearing a small round knob on the top. Noticing that some of them had passed through the post undamaged, I put these aside in a warm place, and was later very pleased to find that about a dozen had hatched. The larvae were reddish brown in colour, fairly active, but not more than one thirty-fifth of an inch in length, the body sparsely covered with short hairs and divided into the normal number of segments, palpi eight-jointed, and antennae of three joints, which were very unequal in size and shape, the last one bearing a long straight hair. The six legs were alike, and were peculiar, inasmuch as they did not end with

the usual claws, but with spoon-shaped expansions, the use of which was not very apparent. The two mandibles projected directly in front and tapered to fine points, slightly notched at the ends, so that when placed together they would form an admirable boring instrument. The larvae were afterwards identified as those of a species of *Mantispa*, a small raptorial insect, having front legs, closely resembling those of a mantis, by means of which the prey is caught and held fast during consumption. They must not, however, be confounded with the Mantidae, which are orthopterous insects, whereas the Mantispides are obviously neuropterous. The life-history of so small a creature is, of course, very difficult to follow, but exceptional interest attaches to the observations of Brauer upon a much larger species of this genus, according to which it affords an excellent instance of hypermetamorphosis. In the early stage above described it makes its way into the cocoon containing the eggs of a spider, and feeds upon the young ones as soon as they are hatched. During this period it undergoes a remarkable change of form, losing its mobile legs and its distinct and rounded head, and assuming a grub-like appearance, which is retained until it again changes into a pupa, and eventually into a perfect *Mantispa*, a flying insect with four lustrous and transparent wings.

R. T. L.

SOURCES OF LIGHT IN MICROSCOPY.—There is no absolutely perfect illuminant for microscopy. For good results with daylight we must have a favourable window and a favourable day. In many places the incandescent gas light is available, and I have myself used it for some years. But there is something to be said in favour of the ordinary flat-wicked oil lamp on the score of simplicity and portability. It does not give off light and heat greatly in excess of what is required. When the adjustments are made satisfactorily, the half-inch wick actually gives a more efficient light for photographic purposes than the large Graetzin mantle. I had always assumed that the mantle was superior to any lamp burning oil until I read Dr. D. J. Reid's article in this year's *British Journal Photographic Almanac*. The exposures required according to his table, using oil lamp and Nelson lens, were shorter than I employ with the mantle and the Kohler system of lenses. I repeated some of my exposures with the oil lamp and Nelson lens, and found that what I consider correct exposure time was at all events not increased. For this surprising result I am inclined to assign three causes. There is actually no great concentration of light in the incandescent mantle; it is the diffusion of the light that gives it advantage as a general illuminant. There is less photographically useful light from the mantle than from the oil lamp, as evidenced by their relative spectra; and the Nelson lens is very much more efficient than other collecting systems. This is because of its very great numerical aperture, or, to use the language of the camera, its very low F / number. Now for the disadvantages of the oil lamp. Good results cannot be obtained unless the edge of the wick is very carefully centred to the lens. This difficulty is overcome by mounting both lamp and lens in a solid manner to fit the optical bench. The lamp has up and down and radial movements, which can be clamped without jerking, besides the usual movement round its own axis. The work was carried out for me under the direction of Mr. H. F. Angus, who made some valuable suggestions as to details. Frequently it is complained that the light from the oil lamp is too yellow, and also that the field tends to be vertically distorted. This is obviated by the more exact focusing permitted by the mounting just described. The size of illuminated field available is certainly not so easily adjusted as in the Kohler system, especially for low powers; but this can be met by using a substage condenser of suitable focal length when low powers are employed. The only other inherent disadvantage of the oil-lamp arrangement is that while the light can be directed upwards at a slight angle, downward direction is much less satisfactory, and it certainly seems better in all cases to use the Nelson lens without any tilting, so that its optic axis is parallel to the bench. When, therefore, it is necessary to supply a beam of light near the level of the table, one must either raise the microscope or transmit the light by two mirrors, arranged as in a trench "periscope." Alternatively, the Nelson lens is replaced by a collecting system of lower power. But for horizontal photomicrography with quite low powers the Nelson lens without substage condenser serves perfectly well. In fact, I am inclined to class this lens with the very few truly and altogether great discoveries.

E. W. BOWELL.

THE QUEKETT MICROSCOPICAL CLUB.—The 509th Ordinary Meeting of the Quekett Microscopical Club was held on Tuesday, June 22nd, 1915, the President, Professor Arthur Dendy, F.R.S., in the chair.

The President stated that as the first meeting to consider the formation of the Club was held on June 14th, 1865, the present meeting marked an epoch in the history of the Quekett Club, as it concluded the first fifty years of work. He pointed out that many interesting notes on the history of the Club are to be found in the April number of the Journal. He then drew attention to the fact that there were now present three of the original members—Messrs. R. T. Lewis, Alphaeus Smith, and T. H. Powell—and expressed a hope that they might long continue to give the Club the pleasure of their attendance.

Dr. John W. Evans of the Geological Department of the Imperial College of Science, South Kensington, then gave a lecture on "The Microscopical Examination of Minerals." The lecture was fully illustrated by diagrams and coloured lantern slides, which were, Dr. Evans pointed out, mostly due to the art of Mr. C. H. Caffyn.

There was a collection of photographs of rock sections on Lumière Autochrome Plates, exhibited by Messrs. J. W. Ogilvy and C. H. Caffyn; also a series of exhibits showing the process of mounting a rock section.

The ordinary meetings of the Club are suspended for the summer, the next being held on October 26th, and gentlemen wishing to attend as visitors are invited to apply for cards of admission to the Honorary Secretary, James Burton, 8, Somali Road, West Hampstead, N.W., or to any of the leading opticians.

PHOTOGRAPHY.

By EDGAR SENIOR.

VARIATIONS IN THE METHODS OF TONING MATT COLLODIO-CHLORIDE PRINTS.—The use of two separate baths in toning matt collodio-chloride prints having been already dealt with, attention will now be given to the variations in colour obtainable by employing a single toning bath of either gold or platinum. When gold is used, the borax bath is generally recommended, although the acetate bath is very satisfactory. In either case, the toning is continued until the desired colour is seen in the prints as they lie in the dish. Some of the nicest colours obtainable are browns or sepia. With some papers a good warm black is obtainable by the use of a platinum bath alone, although it will not yield a pure black, such as is given by toning in the two separate baths. When the platinum bath is used, the formulae already given should be employed. All the operations are the same as in gold-toning, except that on no account must the washing between toning and fixing be neglected, whereas in gold-toning this operation is not necessary. We now come to certain modifications of the single-toning bath, which are useful in producing sepia and dark brown tones.

First method: The prints, which must not be as dark as when intended for black tones, are first washed as quickly as possible in three changes of water, and then put into a bath made up as follows:—

Ammonia, ·880	1 drachm
Water	20 ounces

XUM

In this solution the prints turn a lemon-yellow colour. They are then washed in five or six changes of water, and toned in the borax bath until the desired colour is reached; or, if preferred, the platinum bath already given for black tones may be used diluted to two or three times its volume with water. The prints are then washed and fixed.

Second method: The prints, which should be rather more deeply printed than they should appear when finished, are first washed in two or three changes of water, allowing about five minutes in each; they are then transferred to a weak solution of salt and water, about ten grains in twenty ounces of water. They are left in this until they assume a brick-red colour, when they are washed in two changes of water (each of five minutes' duration), and then transferred to the platinum toning bath, where they are allowed to remain until they have assumed the desired sepia or brown tone. A very thorough washing must then be given (five or six changes of five minutes in each), and the prints then fixed in—

"Hypo"...	...	...	...	3 ounces
Water ...	...	...	...	20 ,,

After fixing, the prints are washed for two hours in running water. Prints of the so-called red-chalk tone may also be obtained by first washing them in two changes of water and then soaking in water containing common salt (about one ounce of salt dissolved in twenty ounces of water) until they become yellow in colour, when they are rinsed well and toned slightly in the borax bath. Other modifications of tone are possible, but those given are the most generally useful. Prints toned with gold should not be washed in the same dish as those toned with platinum, and by whatever method they may have been toned the prints should always be washed for two hours after fixing, in order to ensure reasonable permanency. When every care is taken with the various manipulations, failures will at times occur. In cold, wet weather the prints dry slowly, and yellow spots are liable to make their appearance. Rapid drying should be resorted to. Prints that appear perfect when mounted begin to assume a yellow colour after a few days: this appears to be due to damp left in the print, which very quickly affects its colour. Prints, when removed from the washing water, should be placed on a glass plate, and the excess of water pressed out; after which they should be spread out upon blotting-paper to dry in a warm room. For mounting these prints the safest and best means is to employ the dry-mounting method, as rewetting the prints after they have once become dry is one of the causes of the film cracking. Although there are a good many causes which lead to failure in the working of matt collodio-chloride papers, if ordinary care be exercised, and the delicate nature of the material in use be recognised, there is no reason why success should not attend the process. The advantages of collodio-chloride over gelatino-chloride papers are the small amount of gold required in toning and the beauty of the tones, as well as the ease with which they are obtained; the absence of any gelatine to become soft and tackey, and the smaller amount of care required in the summer months on this account; while if the glossy surface collodion paper is used, the gloss remains uninjured when an aqueous mountant is employed in mounting. Another advantage claimed for matt collodio-chloride paper is that it combines the best features of albumen with that of glossy collodion paper, retaining all the softness that was characteristic of the older albuminised paper print, while retaining the brilliancy of the glossy collodion surface.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.Sc.

THERMIONICS.—This is a name coined by Richardson to indicate that branch of physics which deals with the emission of electricity from hot bodies. In the course of a Friday evening lecture at the Royal Institution (May 7th, 1915), Richardson showed a number of well-designed and striking experiments illustrating the subject. A gold-leaf electroscope was discharged by the presence in its neighbourhood of a red-hot poker. A loop of wire, which could be heated in the air by an electric current, was shown to be capable of holding a negative charge while at a dull red heat, but incapable of retaining a charge of either kind when white hot. In a vacuum a metal such as tungsten, which can be freed from occluded gases, can, by ageing, be made capable of emitting only negative electricity under the influence of heat. Richardson showed that the current (the thermionic current) was carried in this case purely by means of negatively charged corpuscles, bodies which are small compared with the chemical atom. This was demonstrated by proving their ready deflection by a magnetic field. The rate of emission of negative electricity with rise of temperature obeys a formula according to which an enormous increase in emission corresponds with a small increase in temperature. In general shape the curve showing this effect is similar to that in which the vapour pressure of a liquid is plotted against the temperature, and the view taken was that the phenomena are somewhat similar. The thermionic current is to be regarded as a consequence of the evaporation of the electricity, the corpuscle or electron corresponding on this view to the molecule of the evaporating liquid.

THE PHOTOGRAPHIC ACTION OF α, β, AND γ RAYS.—Sahni (*Phil. Mag.*, June, 1915) has carried out a series of very interesting experiments on radio-activity by the photographic method. It was found that most photographic plates and films on development show, under the microscope, a large number of blackened grains, even when they have not been previously exposed to light or some other stimulus, such as radiations from an active substance. But it was found that Wratten and Wainwright's lantern-plate presented an absolutely clear surface. With sources of α rays the tracks of the particles are shown by black lines radiating from the centre of emission of the rays. These are visible under the microscope, and Sahni's paper is accompanied by several microphotographs of the exposed plates. Careful examination of the radiating tracks shows the presence of an occasional sudden deflection of the path due to scattering. In the case of the β ray photographs the radial character of the α photographs is altogether absent. The photographs due to γ rays are similar to the β ray photographs. They can, of course, be obtained through considerable thicknesses of lead. In one case the photographs were taken through a lead plate four centimetres thick. These methods have also been applied to the study of potassium and rubidium, both of which gave off β rays. Sahni intends to apply the method to the accurate investigation of the scattering of α rays by gases.

ALGOL.—This well-known variable star has aroused more interest than any other during the last hundred years. Once in sixty-nine hours the star loses two-thirds of its light, due to the eclipse of the main body by a large and relatively faint companion. This principal eclipse has been known and studied for a century, but it has often been remarked that unless the companion is entirely dark there should be a second eclipse when it passes behind the main body. This decrease in light midway between eclipses, due to the brighter body intercepting the light of its fainter companion, has been detected by Stebbins with the selenium photometer. He calculates that this secondary diminution amounts to six per cent. He finds also a continuous variation between the minima, which shows that the companion is brighter on the side turned toward the primary. Even on its duller side the companion, which has often been called dark, has a surface brightness much greater than that of our Sun.

RADIO-ACTIVITY.

By ALEXANDER FLECK, B.Sc.

ADSORPTION.—The phenomenon of the adsorption of radio-active substances has never been explained. In the case, for instance, of thorium-X being adsorbed by barium sulphate, the result is what one would naturally expect, because thorium-X and barium are chemically similar. When, therefore, barium sulphate is precipitated from a solution of thorium-X and barium there is no cause for surprise that thorium-X should be adsorbed in the precipitate. It is, however, much more difficult to explain why it is that soot, when shaken in a dilute solution of uranium-X, should attract that radio-element to itself, and all explanations which have been put forward until now, and which are usually based on the properties of colloids, have failed to furnish us with a clear idea of the process. Horovitz and Paneth (*Zeitschr. Physikal. Chem.*, Volume 89, page 513) have recently been studying this subject, basing their work on the effects observed by shaking various insoluble substances in solutions of radio-active elements. The experiments were conducted with radium, polonium, thorium-B and thorium-C, and with such compounds as barium sulphate, barium chromate, cupric oxide, manganese dioxide, and silver chloride as adsorbents.

The results obtained show that when an ordinary inorganic compound is shaken with a radio-active element, there is a connection between the quantity of the latter material adsorbed and the solubility of its "analogous" compound.

This, however, does not help in any way to give us any explanation of the case already mentioned, soot and uranium-X, where the chemical dissimilarity is great.

EXPERIMENTS ON RADIUM EMANATION.—A. Debierne, who was one of the earliest experimenters in the subject of radio-activity, has given a long account (*Ann. Physique*, 1915, page 18) of the repetition which he has made of some of the earlier fundamental experiments with radium emanation. His experiences in purifying the emanation are very similar to those published by other workers. He also finds that the volume of radium emanation in equilibrium with one gram of radium is 0·605 cubic millimetre, which is in close agreement with the previously accepted value of 0·60 cubic millimetre.

Debierne also examined the radium emanation to see if he could detect any traces of heterogeneity which various workers have alleged to find. He failed, however, to obtain any evidence that it contained more than one element.

This work has confirmed in a striking manner the values obtained in early experiments, and leads us to believe that in most of the original work in radio-activity a great degree of confidence can be placed.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

LARKS SINGING AT NIGHT.—Gilbert White wrote that "birds that sing in the night are but few," and he instanced the nightingale, the woodlark, and the sedge-warbler. He might have added some more, of course, including the skylark, which is well known to sing very late. On the night of May 23rd, in the vicinity of Aberdeen, the larks were singing at 11 p.m., and they began again at 2 a.m., having been silent for three hours.

CETACEANS ON BRITISH COASTS DURING 1914.—Dr. S. F. Harmer obtained fifty-seven records of stranded cetaceans for 1914, as compared with seventy-six for 1913. The diminution was probably due to the fact that after July the attention of coastguard officers was in part preöccupied by the war. Of the total number of specimens thirty-four may be considered to have been definitely determined. There were at least fifteen common porpoises, four common dolphins, four white-beaked dolphins, three bottle-nosed dolphins, one pilot whale, five bottle-nose whales, one Sowerby's whale (the most interesting record for the year), one common rorqual (sixty-one feet five inches long), and four Rudolphi's rorquals. Attention is drawn to the occurrence of considerable variation in the form of the teeth in the common porpoise.

EELS ABOVE NIAGARA FALLS.—In a report on the fishes of Georgian Bay (part of the Lake Huron waters) Professor B. A. Bensley refers to the occurrence of specimens of the American Eel (*Anguilla chrysypa*) above the Falls. Specimens are reported, on reliable authority, to have been taken occasionally at the mouth of the Severn River and at Waubaushene, at the south-east end of Georgian Bay. "Since the eel spawns in the sea, and the Falls of Niagara offer an insuperable obstacle to the ascent of the young, such specimens as are taken in the upper lakes must be chance specimens that gain access through the canals."

ORGANIC MATTER AT SEA-BOTTOM.—Petersen and Jensen have been investigating the proportion of organic matter on the sea-bottom in Danish waters and inquiring into its origin. They come to the interesting conclusion that in sheltered areas, as in fjords, the organic matter is almost exclusively derived from the *Zostera* belt, and not from the sinking down of plankton organisms. Blegvad is inclined to go further, for he finds that the diatoms and the like of the phyto-plankton are used in their living state only by some of the members of the zoö-plankton, such as Copepods. They are perhaps of more importance when they sink after death to the bottom, and aid in the formation of organic detritus. But a great part of the detritus comes from the shore-area. While there are true carnivores and true vegetarians in the sea, of the majority of marine animals it must be said that they feed on detritus.

ECTOPARASITE OF FRESHWATER JELLY-FISHES.—On many freshwater animals, and on some marine ones as well, there are ectoparasitic infusorians, belonging to the genus *Trichodina*, which rush about on the surface, and probably keep things clean. It is rather interesting that they occur also on the surface of the freshwater jelly-fishes of the Kistna River, in the Presidency of Bombay (*Limnocnida indica*), in the species from Lake Tanganyika (*L. tanganicae*), and in the species of the Zambesi and Limpopo systems (*L. rhodesiae*). So that there seems to be a very constant association between *Trichodina* and *Limnocnida*, just as there is between *Trichodina* and *Hydra*. It may be recalled that the *Trichodina pediculus* on Hydra sometimes mounts on the back of another infusorian, *Keroma polyporum*, and utilises it, as a man might a horse, for easy locomotion!

CURIOUS PHENOMENON IN PIGEON-BREEDING.—The late Professor C. O. Whitman of Chicago, spent many years in the study of pigeons, and it is to be hoped that his unpublished observations will be made available. One of the phenomena which he noticed was that, if certain somewhat distantly related kinds of pigeons be crossed, and if the eggs be taken away as fast as they are laid (so as to induce the pair to continue to lay fertile eggs), then in the spring both eggs of a clutch will usually develop into males, while in the autumn both will usually develop into females. In the transition period the first egg of the clutch usually develops into a male, and the second into a female.

Dr. Oscar Riddle has noticed in this connection that one of the two sister pigeons in the autumnal part of such a series is usually very masculine in her ways, and that the same is true of a female hatched early in the season when most of the clutches result in two males. We get into very deep waters, indeed, when we face the extraordinary fact that, if these masculine females receive injections of the ovarian extract of ordinary females, they come to behave in a normal manner. The sex-behaviour of the bird is probably in part determined by hormones, which pass from the sex-glands to the central nervous system.

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THE GRAPHICS OF GRAVITATION.

By PROFESSOR A. W. BICKERTON, A.R.S.M.

(*Continued from page 206.*)

We have hitherto chiefly dealt with unit force. We alter the resultant force when we alter the slope. Place two laths and marbles as in Figure 215 at slopes 1 and 2. Release the two together; they reach the bottom together, and travel at speeds 1 and 2.

Forces of one and two units have acted for the same time on equal masses, and developed velocities of one and two units. Again, energy is 4; speed is 2.

Or place the laths, as in Figure 216, with slopes 1 to 4 and heights 1 to 16. Release both at once; they reach the bottom together, and travel at speeds 1 and 4. Again, the energy is as the square of the velocity, the energy is 16 and speed 4; and, as the marbles are of equal mass, the kinetol is the same as the energy. The graphics are shown in Figure 217. In this, call the forces $\frac{1}{2}$, 1, and 2.

Make the fall vertical, and call the force 32, that is, about that of gravity, with units of feet and seconds. This force differs in different places; call the speed of a vertical fall 32, and the distance travelled in unit time sixteen feet. In this way we may experimentally and graphically (see Figure 219) deduce all the laws and formulae of falling bodies and of dynamics in general. We may alter the slope and place the marbles at the same height, and show that in different times they gain the same speed on reaching the bottom if they start from the same height; but a book is required to exhaust this method of experimenting, when we alter mass by using heavy balls, and study momentum, elasticity, and so on.

There is one pretty experiment of inertia worth making. Place a number of marbles along a grooved lath, and pull the lath sharply lengthwise. The marbles stand extraordinarily still. This is partly due to the friction tending to produce a rotation in the opposite direction (see Figure 218).

Cosmic Graphics of Gravitation.

If we carry a spring balance some miles up in a balloon, a one-pound weight will stretch it less than on the surface of the Earth. If we could take it up the distance of another radius of the Earth, about four thousand miles, a one-pound weight would stretch the spring only one-fourth the distance it does at the surface. That is, we have the law of inverse squares acting; and, could we at that height repeat the uniform acceleration marble experiments, the marbles would only gain speed at one-quarter the ratio. The weight lessens with the lessened attraction, but the mass and inertia remain the same. If from that height we were to drop a marble to the Earth's surface, on its journey it would increase its acceleration from one-fourth to one. In the first second it would gain a speed of about eight feet a second, and in its last second it would gain a speed of about thirty-two feet a second.

Thus in all cosmic problems of falling bodies we have a varying acceleration to deal with.

Of course, the acceleration is different if the bodies approach one another on a radius or on a conic section. Only a definite measure of nearness gives the same increase of velocity, as we saw in the marble experiments on the inclined planes.

There are five fundamental graphic curves that chiefly interest astrophysicists, although others have been used in special problems. They are shown together in Figure 220. The five are the curves of force, of kinetol, of velocity, of duration, and of time.

The Gravit curve, or curve of Gravon, or of force or attraction, involves weight and pressure; it is the curve of inverse squares. The kinetic curve, or curve of gravitol, is the curve of space or distance travelled: it involves potential, kinetol, and energy. This curve is a rectangular hyperbola, and is the summation of the infinitesimals of the curve of attraction. The curve of velocity is deduced from the curve of kinetol. It involves momentum.

The curve of duration is the inverse of the curve of velocity, and is a parabola.

The curve of time is the summation of the curve of duration. All these curves have been treated with the calculus by different mathematicians, but this mode is rarely of value in cosmological problems.

In these articles the problems will only be treated geometrically. The whole of the vast number of problems involved in the new cyclic cosmology have been solved geometrically. They have frequently been checked by the calculus and by weighing the tracing-paper of the curve area on a chemical balance.

The Five Gravitation Curves.

In all these five curves the abscissae or horizontal lines represent distance from the centre of the body. The vertical heights or ordinates in the first curve represent the force of gravity (see Figure 221).

The curve of kinetol is obtained by taking the area of the curve of attraction. If lines, as that marked A, be drawn from the top of one ordinate to the foot of double the distance from the original centre of gravity it will be seen that it leaves out and takes in about equal areas of the curve.

XUM

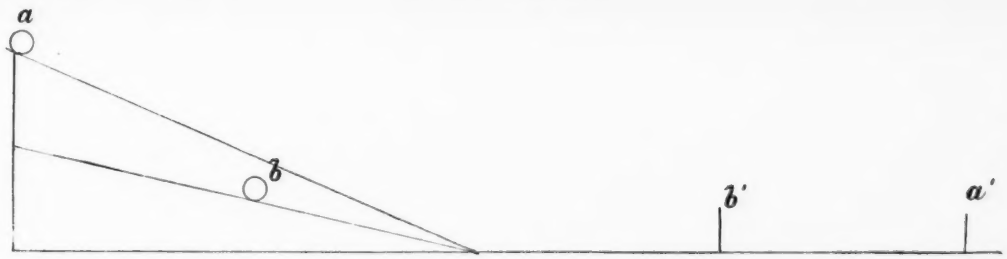

FIGURE 215.

Experiment to illustrate forces 1 and 2. The marbles are liberated together, reach the bottom together, and strike obstacles together. The height of the marbles 1 to 4. K, 1 to 4; V, 1 to 2.

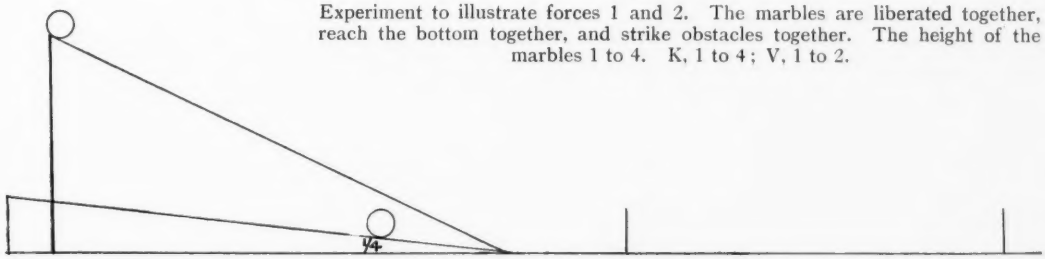

FIGURE 216.

Experiment to show that the velocity is proportional to force. The two marbles are released at the same moment. They reach the bottom together, and acquire velocities 1 to 4. The height they fall from is 1 to 16; hence the kinetols are 1 to 16.

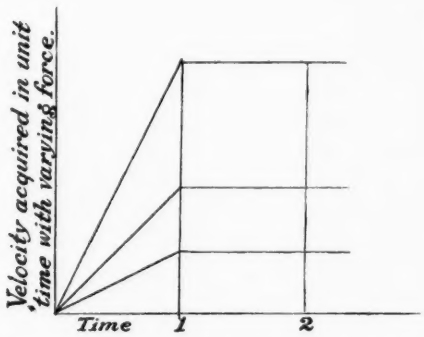

FIGURE 217. Graph showing that in unit time velocity is proportional to force on unit mass, the forces being ½, 1, and 2.

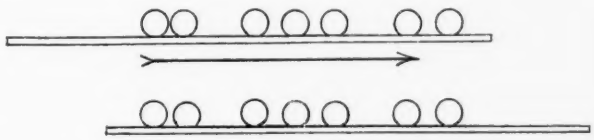

FIGURE 218. Experiment of quickly pulling a grooved lath under marbles to show inertia.

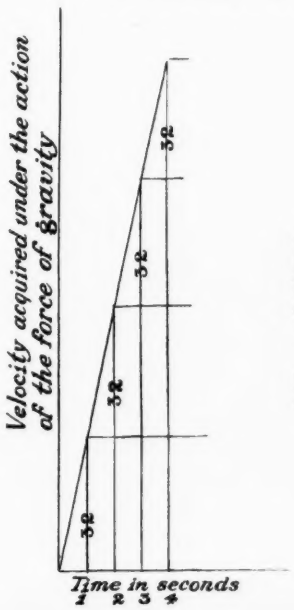

FIGURE 219.

Graph showing that kinetol is force multiplied by half time or velocity squared; also that distance fallen is $32 \times \frac{T^2}{2}$.

Note the horizontal and vertical scale is not the same.

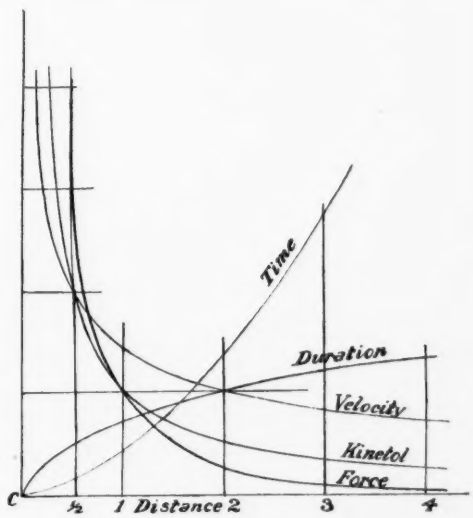

FIGURE 220. Graphics of gravitation. The five curves compared. Unit mass and parabolic velocity are assumed.

XUM

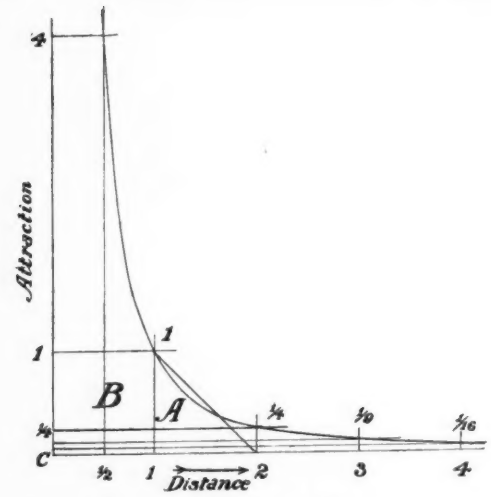

FIGURE 221. The gravit curve.

The attraction at any distance is found by the vertical distance to the curve. The triangle A is equal to half rectangle or square B.

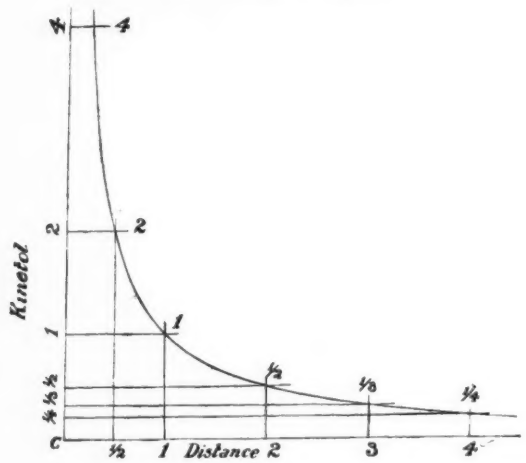

FIGURE 222.

The kinetic curve, or curve of potential, of gravitol, kinetol, or energy.

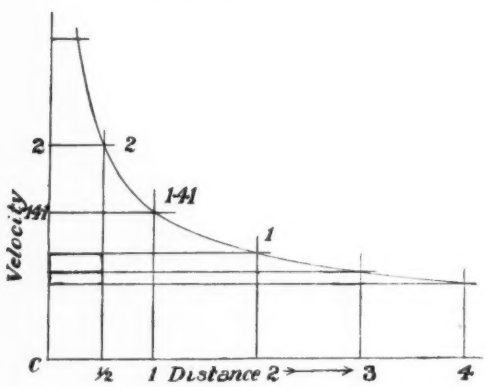

FIGURE 223.

Velocity curve, or curve of parabolic velocity. The curve of momentum.

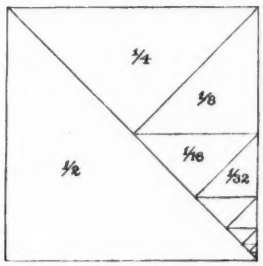

FIGURE 224.

Diagram showing that the summation to infinity of the curve of attraction is unity.

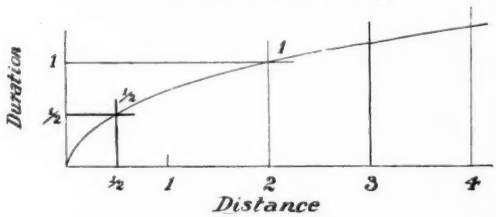

FIGURE 225.

Duration curve, or curve of the time a particle at parabolic velocity takes to pass an infinitesimal of distance.

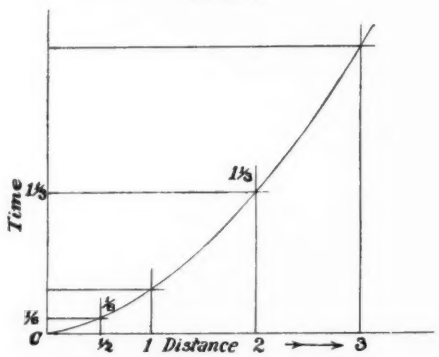

FIGURE 226. The curve of time.

The difference in the height of the ordinates tells the time a body at parabolic velocity will take to move any distance on a radial line.

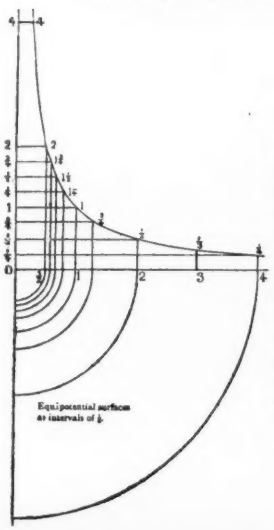

FIGURE 227.

The kinetic curve.

An equilateral hyperbola curve of potential, of kinetol, of thermatol, or of gravon. Horizontal lines represent distance from Sun's centre; vertical lines represent potential, and so on. The work required to pass from 4 to infinity is equal to the passing from any one equipotential surface to the next.

The two surfaces can be proved to be equal, both by the calculus and by the balance; but for problems of impact the eye is as accurate as the facts of observation. Hence we see that the area A of the curve is half the square B, the next is a quarter, the next again is one-eighth, and so on, to infinity. In this way we just fill the square (see Figure 224).

Thus the area of the curve is the sum of the infinitesimals, whose length is the force, and thickness the distance travelled. Now force multiplied by distance is energy, and energy divided by mass is kinetol. Kinetol is a simpler conception than energy: it is energy with the value of mass left out. It is the kinetic energy of unit mass. It fortunately happens that in nearly all spectrographic problems velocity is the important factor, and that is deduced from kinetol. We have seen that kinetol is $\frac{V^2}{2}$, that is, it is proportional to V^2. This simplification of cosmic problems has greatly facilitated the study of cosmology. The kinetic curve is shown in Figure 222.

Hence the ordinates of our kinetic curve, as we successively double the distance, are 1, $\frac{1}{2}$, $\frac{1}{4}$, and so on: not these numbers squared; and the curve that joins the tops of the ordinates is the rectangular hyperbola, a remarkably simple curve, and one of great importance in many branches of science. It is the curve of inverse proportion, not of inverse square. Think how very easy it is to say, at three hundred times the distance from a body, the kinetol is $\frac{1}{300}$ part. Kepler's third law is: "The squares of the periodic times of the revolutions of the planets are proportional to the cubes of their distances." By the use of this valuable new term the law becomes: The kinetol of a planet is inversely as its distance from the centre of the Sun.

This simple curve is probably the most important one in the study of the dynamics of the whole realm of nature. It enables cosmic problems to be profitably studied in the fourth form of a school.

As kinetol is half velocity squared, our velocity curve is found by taking the square root of twice the ordinates of the kinetic curve. The ordinate 1 becomes $\sqrt{2}$; 2 becomes $\sqrt{2\times2}=2$; $\frac{1}{2}$ becomes $\sqrt{\frac{1}{2}\times2}=1$, and so on (see Figure 223).

The fourth curve—that of duration—represents the length of time a body takes to pass an infinitesimal of a given distance from the centre of attraction. Its chief value is that its summation gives us the time a body moving on a radius will take to travel any given distance. The ordinate of duration is the inverse of the ordinate of velocity; 2 becomes $\frac{1}{2}$, 1 remains 1, $\frac{1}{2}$ becomes 2, and so on (see Figure 225).

The fifth curve—that of time.—The ordinates are obtained by the summation of the curve of duration, which is a parabola; and, as the area of a parabola is two-thirds the circumscribing rectangle, the ordinates of the curve are easily obtained. Hence, for the ordinate 1 at distance 2 it is $\frac{2}{3}$ of 2; for the ordinate of $\frac{1}{2}$ it is $\frac{2}{3}$ of $\frac{1}{2^2}=\frac{1}{6}$, and so on (see Figure 226). Thus the time a body will be on a radius from, say, half distance to twice distance is the difference in the height of the respective ordinates. When once the curves are drawn the solution of the varied problems are simply matters of measurement.

Figure 220 shows the relation of the five curves to one another, and Figure 227 represents a section of the equipotential spherical surfaces surrounding a sun. This diagram shows how large an amount of work is done when two bodies approach near to one another. In fact, so little is done at great distances that, instead of the term "infinity," the term "a light-year" may be substituted in all problems of solar collision. But it will be seen in our next article that the scale of the idea of the term infinity varies with the volume involved. The application of these curves to solar and cosmic problems will be given in the next article.

(*To be continued.*)

MR. FRANK C. DENNETT.

OUR readers will miss this month the article on "Solar Disturbances" which has been a long-standing feature of "KNOWLEDGE." The reason is a sad one, for Mr. Frank C. Dennett, our contributor, has had a sudden and serious illness, which has completely incapacitated him. We hear, however, that he is somewhat better, and is looking forward to sending in his notes again before very long.

XUM

THE FACE OF THE SKY FOR SEPTEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 41.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m	°	h. m.	°
Sept. 3	10 45·7	N. 7·9	6 1·8	N.27·3	11 49·6	N. 1·5	10 38·4	N.10·1	6 42·1	N.23·5	23 45·3	S. 3·3	6 59·5	N.22·2	21 1·3	S.17·7
,, 8	11 3·8	6·0	10 17·4	N. 9·1	12 17·1	S. 2·2	11 1·7	7·8	6 55·7	23·3	23 43·0	3·5	7 1·3	22·1	21 0·7	17·7
,, 13	11 21·8	4·1	14 32·8	S. 20·5	12 42·8	5·6	11 24·8	5·3	7 8·9	23·1	23 40·6	3·8	7 3·1	22·1	21 0·1	17·8
,, 18	11 39·8	2·2	19 41·5	S. 23·5	13 6·8	8·9	11 47·6	2·8	7 22·6	22·8	23 38·2	4·1	7 4·7	22·0	20 59·5	17·8
,, 23	11 57·7	N. 0·3	23 56·4	N. 3·5	13 28·7	11·7	12 10·4	N. 0·3	7 34·7	22·4	23 35·7	4·3	7 6·2	22·0	20 59·0	17·8
,, 28	12 15·7	S. 1·7	3 58·0	N.25·5	13 48·1	S. 14·2	12 33·2	S. 2·2	7 47·2	N.22·0	23 33·3	S. 4·6	7 7·4	N.22·0	20 58·6	S.17·9

TABLE 42.

Date.	Greenwich Noon. Sun. P	Sun. B	Sun. L	Moon. P	Greenwich Midnight. Mars. P	Mars. B	Mars. L	Mars. T	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2
	°	°	°	°		°	°	°	h. m.					
Sept. 3 ..	+ 21·6	+7·2	95·9	+ 1·6	Sept. 1 ..	−21·1	+ 5·3	226·9	8 27 *m*	Sept. 4 ..	−25·5	+2·2	227·8	124·5	5 46 *e*	8 34 *e*
,, 8 .	22·7	7·3	29·9	+20·6	,, 7 .	19·1	6·8	168·8	0 26 *e*	,, 11 ..	25·4	2·2	254·1	97·4	5 3 *e*	9 19 *e*
,, 13 ..	23·7	7·2	323·9	+16·4	,, 13 ..	17·1	8·2	110·8	4 24 *e*	,, 18	25·4	2·2	280·4	70·2	4 20 *e*	10 4 *e*
,, 18 ..	24·6	7·1	257·8	−10·9	,, 19 ..	15·0	9·6	52·9	8 23 *e*	,, 25 ..	25·4	2·2	306·5	43·0	3 37 *e*	10 49 *e*
,, 23 ..	25·3	7·0	191·8	−22·5	,, 25 .	13·0	10·9	355·0	—	Oct. 2 ..	−25·4	+2·1	332·6	15·6	2 55 *e*	11 34 *e*
,, 28 ..	+ 25·8	+6·8	125·8	−10·0	Oct. 1 ..	−10·9	+12·1	297·1	3 39 *m*							

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. In the case of Jupiter System I refers to the rapidly rotating equatorial zone, System II to the temperate zones, which rotate more slowly. To find intermediate passages of the zero meridian of either system across the centre of the disc, apply to T_1 T_2 multiples of $9^h\ 50^m{\cdot}4$, $9^h\ 55^m{\cdot}6$ respectively. In the case of Mars apply multiples of $24^h\ 40^m$.

The data for the Moon and Planets in the Second Table are given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN is moving Southward at its maximum rate, and crosses the Equator (autumnal equinox) at $3^h\ 24^m$ *m* on 24th. Its semi-diameter increases from 15′ 52″ to 16′ 0″. Sunrise changes from $5^h\ 13^m$ to $5^h\ 59^m$; sunset from $6^h\ 47^m$ to $5^h\ 41^m$. There is now considerable solar activity, and a constant watch should be kept on the disc.

MERCURY is an evening star throughout the month, at greatest elongation 26° E. of Sun on 28th. Semi-diameter increases from 2½″ to 3½″. Illumination diminishes from $\frac{9}{10}$ to $\frac{1}{2}$. The bright star Spica in Virgo will be 1′ South of Mercury at 3^h *e* on 21st. The phenomenon may be seen in daylight in the British Isles. So close an approach of a planet to a first-magnitude star is rare.

VENUS is practically invisible, being in superior conjunction with the Sun on the 12th. Semi-diameter 5″, illumination Full.

THE MOON.—Last quarter $1^d\ 2^h\ 57^m$ *e*. New $9^d\ 10^h\ 53^m$ *m*. First quarter $16^d\ 7^h\ 21^m$ *m*. Full $23^d\ 9^h\ 35^m$ *m*. Apogee $1^d\ 9^h$ *e*, $29^d\ 5^h$ *e*. Perigee $14^d\ 3^h$ *e*, semi-diameter 14′ 48″, 14′ 48″, 16′ 12″ respectively. Maximum librations 8° 5° E., 13^d 7° N., 22^d 5° W., 27^d 7° S. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon (see Table 45).

MARS is a morning star, rising about midnight. It is 6° South of Pollux on 25th. Semi-diameter 3″, width of defective lune $\frac{2}{3}$″. The North Pole of the planet is now turned towards the Earth, but the South Pole to the Sun, the planet being in the part of its orbit that corresponds with early March on Earth.

JUPITER is in opposition to the Sun on the 17th, when it rises at sunset and sets at sunrise. It is in Pisces: Equatorial diameter 50$\frac{1}{2}$″, Polar 47″. Illumination Full.

Configuration of satellites at midnight for an inverting telescope (*i.e.*, the midnight at the end of the given day).

JUPITER'S SATELLITES.

Day.	West.	East.	Day.	West.	East.
Aug. 1	24 ○	3 1●	Aug. 16	2 ⊙	$\frac{3}{4}$
,, 2	41 ○	3 2●	,, 17	34 ○	12
,, 3	43 ○	12	,, 18	341 ⊙	
,, 4	4312 ○		,, 19	432 ○	1
,, 5	432 ○	1	,, 20	413 ○	2
,, 6	41 ○	32	,, 21	4 ○	123
,, 7	4 ○	123	,, 22	421 ○	3
,, 8	24 ○	3 1●	,, 23	42 ○	13
,, 9	1 ○	234	,, 24	43 ○	12
,, 10	3 ○	124	,, 25	314 ⊙	
,, 11	312 ○	4	,, 26	32 ○	14
,, 12	32 ○	14	,, 27	13 ○	24
,, 13	1 ○	24 3●	,, 28	○	1234
,, 14	○	1234	,, 29	21 ○	34
,, 15	21 ○	34	,, 30	2 ○	134

The following satellite phenomena are visible at Greenwich:—$1^d\ 0^h\ 12^m$ *m* I. Sh. I., $0^h\ 39^m$ I. Tr. I., $1^h\ 15^m$ *m*

IV. Sh. E., $2^h\ 30^m\ m$ I. Sh. E., $2^h\ 55^m\ m$ I. Tr. E., $2^h\ 55^m\ m$ IV. Tr. I., $3^h\ 12^m\ m$ II. Sh. I., $4^h\ 6^m\ m$ II. Tr. I., $4^h\ 25^m\ m$ IV. Tr. E., $9^h\ 32^m\ 4^s\ e$ I. Ec. D.; $2^d\ 0^h\ 11^m\ m$ I. Oc. R., $8^h\ 58^m\ e$ I. Sh. E., $9^h\ 21^m\ e$ I. Tr. E., $9^h\ 40^m\ 41^s\ e$ II. Ec. D.; $3^d\ 1^h\ 12^m\ m$ II. Oc. R., $4^h\ 14^m\ m$ III. Sh. I.; $4^d\ 7^h\ 22^m\ e$ II. Sh. E., $8^h\ 0^m\ e$ II. Tr. E.; $6^d\ 10^h\ 24^m\ e$ III. Oc. R.; $7^d\ 4^h\ 58^m\ 12^s\ m$ I. Ec. D.; $8^d\ 2^h\ 7^m\ m$ I. Sh. I., $2^h\ 22^m\ m$ I. Tr. I., $4^h\ 24^m\ m$ I. Sh. E., $4^h\ 38^m\ m$ I. Tr. E., $11^h\ 27^m\ 0^s\ e$ I. Ec. D.; $9^d\ 1^h\ 55^m\ m$ I. Oc. R., $8^h\ 35^m\ e$ I. Sh. I., $8^h\ 48^m\ e$ I. Tr. I., $10^h\ 53^m\ e$ I. Sh. E., $11^h\ 4^m\ e$ I. Tr. E.; $10^d\ 0^h\ 15^m\ 52^s\ m$ II. Ec. D., $3^h\ 25^m\ m$ II. Oc. R., $8^h\ 21^m\ e$ I. Oc. R.; $11^d\ 7^h\ 8^m\ e$ II. Sh. I., $7^h\ 28^m\ e$ II. Tr. I., $10^h\ 0^m\ e$ II. Sh. E., $10^h\ 16^m\ e$ II. Tr. E.; $13^d\ 10^h\ 26^m\ 45^s\ e$ III. Ec. D.; $14^d\ 1^h\ 41^m\ m$ III. Oc. R.; $15^d\ 4^h\ 1^m\ m$ I. Sh. I., $4^h\ 5^m\ m$ I. Tr. I.; $16^d\ 1^h\ 22^m\ 2^s\ m$ I. Ec. D., $3^h\ 39^m\ m$ I. Oc.R., $10^h\ 30^m\ e$ I. Sh. I., $10^h\ 31^m\ e$ I. Tr. I.; $17^d\ 0^h\ 47^m\ m$ I. Tr. and Sh. E., $2^h\ 50^m\ m$ II. Oc. D., $6^h\ 43^m\ e$ IV. Tr. E., $7^h\ 24^m\ e$ IV. Sh. E., $7^h\ 48^m\ e$ I. Oc. D., $10^h\ 4^m\ e$ I. Oc. R.; $18^d\ 7^h\ 13^m\ e$ I. Tr. E., $7^h\ 16^m\ e$ I. Sh. E., $9^h\ 43^m\ e$ II. Tr. I., $9^h\ 46^m\ e$ II. Sh. I.; $19^d\ 0^h\ 31^m\ m$ II. Tr. E., $0^h\ 37^m\ m$ II. Sh. E.; $20^d\ 6^h\ 53^m\ 44^s\ e$ II. Ec. R.; $21^d\ 2^h\ 6^m\ m$ III. Oc. D., $5^h\ 22^m\ 27^s\ m$ III. Ec. R.; $23^d\ 3^h\ 6^m\ m$ I Oc. D.; $24^d\ 0^h\ 14^m\ m$ I. Tr. I., $0^h\ 24^m\ m$ I. Sh. I., $2^h\ 31^m\ m$ I. Tr. E., $2^h\ 42^m\ m$ I. Sh. E., $5^h\ 3^m\ m$ II. Oc. D., $6^h\ 29^m\ e$ III. Tr. E., $7^h\ 21^m\ e$, III. Sh. E., $9^h\ 32^m\ e$ I. Oc. D., $11^h\ 58^m\ 51^s\ e$ I Ec. R.; $25^d\ 6^h\ 40^m\ e$ I. Tr. I., $6^h\ 53^m\ e$ I. Sh. I., $8^h\ 57^m\ e$ I. Tr. E., $9^h\ 10^m\ e$ I. Sh. E., $10^h\ 17^m\ e$ IV. Oc. D., $11^h\ 58^m\ e$ II. Tr. I.; $26^d\ 0^h\ 24^m\ m$ II. Sh. I., $2^h\ 46^m\ 4^s\ m$ IV. Ec. R., $2^h\ 46^m\ m$ II. Tr. E., $3^h\ 15^m\ m$ II. Sh. E., $6^h\ 27^m\ 41^s\ e$ I. Ec. R.; $27^d\ 6^h\ 10^m\ e$ II. Oc. D., $9^h\ 29^m\ 22^s\ e$ II. Ec. R. Before opposition Eclipse Disappearances occur on the south-west side of the disc, after opposition Eclipse Reäppearances occur on the south-east side. One visible effect of opposition is the partial covering of the shadows of the inner satellites by the satellites themselves.

SATURN is a morning star in Gemini. 1° 9′ South of Mars on 10th. Angle P − 7°·0, B − 24°·3. Polar semi-diameter $8\frac{1}{4}''$, Major axis of ring 40″, minor $16\frac{1}{2}''$. Eastern elongations of Tethys (every fourth given) $17^d\ 3^h\cdot 7\ e$, $25^d\ 4^h\cdot 9\ m$; of Dione (every third given) $18^d\ 9^h\cdot 9\ e$, $27^d\ 3^h\cdot 0\ m$; of Rhea (every second given) $17^d\ 11^h\cdot 8\ e$, $27^d\ 0^h\cdot 7\ m$. For Titan and Japetus E., W. stand for Eastern and Western elongations; S., I. for Superior and Inferior Conjunctions. Titan $4^d\ 4^h\cdot 8$ I., $8^d\ 3^h\cdot 2\ e$ W., $12^d\ 4^h\cdot 4\ e$ S., $16^d\ 5^h\cdot 6\ e$ E., $20^d\ 4^h\cdot 0\ e$ I., $24^d\ 2^h\cdot 2\ e$ W., $28^d\ 3^h\cdot 3\ e$ S. Japetus $19^d\ 7^h\ e$ E.

URANUS is an evening Star, 7′ South of θ Capricorni on 4th. Semi-diameter $1\frac{1}{4}''$. Close to Moon on North side on 19th at $9^h\ e$.

NEPTUNE is a morning Star in Cancer. On 3rd R.A. $8^h\ 15^m\cdot 1$, N. Dec. 19°·5, on 27th R.A. $8^h\ 17^m\cdot 7$, N. Dec. 19°·4. Semi-diameter 1″.

COMETS.—Mellish's Comet, *a* 1915, may be seen as a morning star low in the South East just before dawn. The following orbit is by E. Millosevich: Perihelion, 1915, July 17·157 Greenwich Mean Time, Omega 247° 46′ 46″, Node 72° 16′ 20″, Inclination 54° 47′ 25″, log perihelion dist. 0·00225 (see Table 43).

The Comet may be faintly visible to the naked eye in September. It exhibited some interesting physical features in May, having two subsidiary nuclei, which were receding from the principal one with considerable speed.

TABLE 43. EPHEMERIS FOR 11 P.M.

Date.	R.A.	S. Dec.	Date.	R.A.	S. Dec.
	h. m. s.	° ′		h. m. s.	° ′
Sept. 1	6 29 9	23 7	Sept. 17	6 25 26	19 56
,, 5	6 28 58	22 16	,, 21	6 23 4	19 12
,, 9	6 28 19	21 28	,, 25	6 20 2	18 28
,, 13	6 27 10	20 42	,, 29	6 16 17	17 46

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
	°	°	
June—Sept. ...	335	+ 57	Swift.
July 25-Sept. 15	48	+ 43	Swift, streaks.
,, —Sept. ...	335	+ 73	Swift, short.
,, —Oct. ..	355	+ 72	Swift, short.
Aug.—Sept. ...	353	− 11	Rather slow.
,, —Sept. ..	346	0	Slow.
,, —Oct. 2...	74	+ 42	Swift, streaks.
,, —Sept. ...	63	+ 22	Swift, streaks.
Sept. 5—15 ...	62	+ 35	Swift, streaks.
,, 6—17 ..	106	+ 52	Swift, streaks.
,, 15—24 ..	14	+ 6	Slow.
,, 21 ...	31	+ 19	Slow, trains.
,, 27—30 ...	4	+ 28	Slow.
,, 28—Oct. 9	320	+ 40	Slow, small.

GREENWICH TIMES OF MERIDIAN TRANSIT OF CERTAIN BRIGHT STARS.—These are given to facilitate the determination of time by observations with small transit instruments. The times for intermediate days may be obtained by simple interpolation. The Greenwich time of the stars crossing the meridians of other places may be obtained by expressing the longitude of these places in time, diminishing them by $9^s\cdot 83$ per hour, and proportionately for fractions of an hour, then applying the result to the tabular time—positively for west longitudes, negatively for east ones.

SUN after clock Sept. 1, $13^s\cdot 07$; Sun before clock Sept. 6, $83^s\cdot 26$, Sept. 11, $184^s\cdot 95$, Sept. 16, $290^s\cdot 08$, Sept. 21, $396^s\cdot 46$, Sept. 26, $501^s\cdot 33$, Oct. 1, $601^s\cdot 75$. These are the equations of time for the moment of solar transit at Greenwich.

TABLE 44.

Day.	Altair. N. Dec. 8° 39′.	α Cygni. N. Dec. 44° 59′.	β Pegasi. N. Dec. 27° 38′.
	h. m. s.	h. m. s.	h. m. s.
Aug. 29	9 18 43·72 *e*	10 10 28·23 *e*	0 31 12·79 *m**
Sept. 8	8 39 24·15 *e*	9 31 8·63 *e*	11 51 53·38 *e*
,, 18	8 0 4·53 *e*	8 51 48·97 *e*	11 12 33·93 *e*
,, 28	7 20 44·91 *e*	8 12 29·30 *e*	10 33 14·46 *e*

* Morning of August 30th.

TABLE 45. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance.		Reäppearance.	
			Time.	Angle from N. to E.	Time.	Angle from N. to E.
1915.			h. m.	°	h. m.	°
Sept. 2 ...	BD+26°·884	6·8	—	—	10 47 *e*	219
,, 6 ...	WZC 569	7·2	—	—	2 0 *m*	190
,, 7 ...	BD+ 15°·2027	6·5	4 44 *m*	22	4 47 *m*	17
,, 14 ...	4 Scorpii	5·6	7 41 *e*	49	—	—
,, 19 ...	Rumker 8872	6·6	11 2 *e*	35	—	—
,, 21 ...	67 Aquarii	6·3	7 0 *e*	44	8 6 *e*	253
,, 22 ...	BAC 7986...	5·9	3 0 *m*	61	3 59 *m*	238
,, 22 ...	BAC 7993	6·4	4 11 *m*	93	—	—
,, 22 ...	WZC 1569	7·4	6 18 *e*	49	—	—
,, 26 ...	BAC 650	6·5	5 44 *m*	31	6 35 *m*	293
,, 28 ...	19 Tauri	4·4	3 13 *m*	102	4 28 *m*	229
,, 28 ...	21 Tauri	5·9	3 40 *m*	93	5 0 *m*	241
,, 28 ...	22 Tauri	6·5	3 47 *m*	101	5 2 *m*	233
,, 28 ...	18 Tauri	5·6	4 1 *m*	349	4 7 *m*	342
,, 28 ...	20 Tauri	4·0	4 2 *m*	155	4 18 *m*	178
,, 28 ...	χ Tauri	5·4	7 32 *e*	69	8 23 *e*	265

From New to Full disappearances occur at the Dark Limb, from Full to New reäppearances.
Attention is called to the occultation of the Pleiades on the morning of Sept. 28.

TABLE 46. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m. s.	° ′		d.	
T Ceti	0 17 28	−20 32	5·4 to 6·9	162	1915—Oct. 5
R Arietis	2 11 17	+24 40	7·3 to 13·2	187	,, Oct. 1
R Tauri	4 23 38	+ 9 58	7·4 to 13·8	325	,, Sept. 21
U Orionis	5 50 47	+20 10	5·8 to 12·1	375	,, Sept. 11
R Geminorum	7 2 14	+22 51	6·6 to 13·2	370	,, Sept. 25
R Cancri	8 11 53	+11 59	6·5 to 11·0	362	,, Aug. 31
T Ursae Maj.	12 32 33	+59 57	5·5 to 12·7	257	,, Oct. 12
V Ursae Min....	13 37 10	+74 45	7·5 to 8·7	71	,, Oct. 7
V Boötis	14 26 19	+39 14	6·4 to 11·3	259	,, Oct 8
X Ophiuchi	18 34 17	+ 8 46	6·5 to 9·5	335	,, Oct. 15
AF Cygni	19 27 40	+45 58	6·9 to 8·0	94	,, Sept. 4
V Cygni	20 38 34	+47 50	6·8 to 13·8	418	,, Oct. 13

Minima of Algol September $4^d\ 4^h\cdot2\ m$, $7^d\ 1^h\cdot0\ m$, $9^d\ 9^h\cdot8\ e$, $12^d\ 6^h\cdot6\ e$, $27^d\ 2^h\cdot7\ m$, $29^d\ 11^h\cdot5\ e$. Period $2^d\ 20^h\ 48^m\cdot9$.
Principal Minima of β Lyrae September $11^d\ 2^h$, September 24^d Noon. Period $12^d\ 21^h\ 47^m\cdot5$.

DOUBLE STARS AND CLUSTERS.—The tables of these, given three years ago, are again available, and readers are referred to the corresponding month of three years ago.

VARIABLE STARS.—Stars reaching their maxima in or near September, 1915, are included. The lists in recent months may also be consulted (see Table 46).

REVIEWS.

CRYSTALLOGRAPHY.

Crystallography: an Outline of the Geometrical Properties of Crystals.—By T. L. WALKER, M.A., Ph.D. 204 pages. 235 figures. 9-in. × 6-in.

(The McGraw-Hill Book Co. Price 8/4 net.)

Although Miller was the first to use the method of coördinates in the measurement of crystals, two-circle goniometry owes its main development to Continental crystallographers, particularly Federov and Goldschmidt, the work of the latter being especially responsible for the extensive utilisation of this method. Professor Walker's aim in writing this book is to present to English readers an outline of crystallography considered from the point of view of Goldschmidt's methods. While the author has written a book which should prove useful as a general introduction to crystallography, he has not been quite successful in confining it to two-circle methods, or even in giving a complete account of the latter. The chief advantage of the theodolite goniometer lies in the fact that the complete measurement of a crystal may be carried out by a single adjustment, while the one-circle instrument requires from three to five separate settings. On the other hand, the former method offers several difficulties to the beginner, particularly in the determination of zonal relationships, and it is unfortunate that this part of the subject receives such scanty treatment. Hutchinson's discovery of the identity of colemanite and neocolemanite exemplifies the prevalence of this difficulty even in accurate goniometry.

The discussion of the thirty-two crystal classes and their symmetry is along conventional lines, but no mention is made of alternating axes of symmetry, while Miller's and Goldschmidt's symbols seem to be used indiscriminately, the latter being generally employed in both the stereographic and gnomonic projections, and the former in the crystal drawings. Although it is generally considered better nowadays to distinguish between the hexagonal and trigonal systems, these two are classed together in this

book, and both are invariably referred to four axes. The chapter on the internal structure of crystals is not very satisfactory, as it does not go much beyond Hauy's observations, while the distinction between "crystalline" and "crystallised" substances (analogous to the petrographical terms "anhedral" and "subhedral" respectively) is not one which is commonly recognised. The replacement, in the last chapter, of the usual "worked-out" examples by reprints of some original papers is to be commended as giving the student a wider idea of the problems of crystallography. The letterpress is excellent and misprints are rare, the only serious one occurring on page 6. We trust that the spelling "lavo-rotary" is also a misprint, as it is scarcely consistent with the spelling "hematite."

A. S.

ENGINEERING.

The Panama Canal.—By R. E. BAKENHUS, S.B., HARRY S. KNAPP, and E. R. JOHNSON, PH.D., SC.D. 257 pages. 20 illustrations. 6 maps. 9-in. × 6-in.

(Chapman & Hall. Price 10/6 net.)

In reading this most interesting account of the greatest engineering work ever undertaken and brought to a satisfactory conclusion, one cannot help admiring the men who had not only the audacity to conceive such a project, but also the necessary energy, ability, and genius to carry it through, notwithstanding the climatic, geographical, and elemental difficulties.

The views and photographs given of the work at various stages are highly instructive, and lead one to assume that absolutely nothing was ignored or left unprovided for; in some instances most elaborate plants have been erected to cope with possible emergencies. A very complete set of plans (longitudinal and cross-section) which is appended to the volume serves to substantiate this impression, as otherwise some apparent unnecessary deviations in the route adopted become inexplicable. From these some idea can also be obtained of the enormous amount of preliminary work found necessary in the way of preparing, working up to, and consolidating the final canal.

On page 114 we find three tables of estimates, varying roughly from one hundred and forty to two hundred and ninety-eight million dollars. That the final accounts showed a total expenditure of only two hundred and twenty-three millions was owing to a reduction of sixty millions on the administrative account; a circumstance quite in keeping with other marvels of the work under consideration, the management item proving so often to be the *bête noire* and stumbling block of similar contracts.

The volume would be of more value from an engineering point of view were the latter half (which treats purely of the commercial, naval, and economic features of the canal) considerably reduced, thus allowing space for more figures and statistics of the work actually carried out. It is doubtless highly instructive to know the cost per cubic yard of such and such a cutting, but the actual quantity is just as important to know, and there is a marked absence of such figures all through the volume.

One must, however, bear in mind that the writers intended to give a general survey of the whole scheme from its commencement, and in this they have undoubtedly succeeded. It can have fallen to the lot of few men to dabble in millions of dollars and cubic yards to the extent they did, and all honour is due to them for carrying out the enterprise so magnificently.

W. G. STEWART.

EVOLUTION.

Evolution and the War.—By P. CHALMERS MITCHELL, F.R.S. 114 pages. 7½-in. × 5-in.

(John Murray. Price 2/6 net.)

Dr. Mitchell's book is, for the most part, an argument to prove that wars between nations are not part of the struggle for existence which some people, including the Germans, have interpreted as being the active extermination of unfit animals and plants by the fit in the course of evolution by natural selection.

Nations are by no means the same as races, and rival countries may consist of the same mixture of people. In order that his line of thought may be understood, the writer has taken considerable pains to explain the present attitude of scientific men, including himself, towards evolution, which is accepted, and which is still a hypothesis.

Many interesting cases are brought forward, such as that of the dingo, which replaced the phylacine in Australia—not by active extermination, but rather by the sort of competition which we see between nations in peace time. Instances are also mentioned of species which, like the black rat and the English cockroach, have wrongly been supposed to have been ousted by the brown rat and the "black-beetle" respectively.

Dr. Mitchell is familiar with Germany, and the notes which he made as to the foreign relations of that country only ten years after the Franco-Prussian War will be read with interest in his introduction. He draws a line between unconscious animals and conscious man, saying that the conduct of the latter is not to be judged by the laws of the former, but by its harmony with a real and external not-self that man has built up through the ages.

W. M. W.

GEOLOGY.

An Introduction to the Geology of New South Wales.—By C. A. SUSSMILCH, F.G.S. Second edition. 269 pages. 92 illustrations and maps. 7½-in. × 5-in.

(Sydney: Angus & Robertson. Price 7/6.)

The study of the geology of our great dominions and dependencies proceeds apace, and is much fostered by mining enterprise, although the official geological surveys are too often hampered by lack of the necessary funds to carry on their work as extensively as they could wish. Nevertheless, the progress of the work is marked from time to time by the publication of memoirs, such as the one under review, upon the regional geology of a State. This compilation of the geology of New South Wales was made primarily as an aid to Australian students, but it is also of great use to teachers, mining men, and others, as shown by the publication of a revised and enlarged second edition. Naturally in such a vast area as that of New South Wales many blanks exist in our geological knowledge, and much of the published work is still of the nature of reconnaissance. Mr. Sussmilch has compiled a readable and most useful book out of the comparatively scarce and scattered material at his disposal. His introductory chapter is historical, and the second deals with the physical geography of the State. Succeeding chapters take up the study of the various geological formations which have been found in New South Wales in order of age; whilst the last gives an account of the igneous rocks, with a table of selected chemical analyses. All the great geological formations are represented in the State, including one—the Permo-Carboniferous—unfamiliar in this part of the world, but representing a natural division of the Australian geological record. This formation contains the great coal strata of New South Wales, and is further remarkable in containing a rock-series indicative of a glacial period. True moraine deposits belonging to the same horizon are known in neighbouring States, but in New South Wales they are represented by marine deposits into which glaciated pebbles and large erratics were dropped by floating ice. The Permo-Carboniferous Glacial period is only one of the many interesting problems presented by the geology of New South Wales, and touched upon briefly in this excellent book. The ninety-two photographic illustrations give a good idea of the wealth of New South Wales in beautiful scenery. There are some successful photographs of Australian fossils and a colour-printed geological map, which is not quite so successful.

G. W. T.

A First Book of Geology.—By ALBERT WILMORE, D.SC. 141 pages. 74 illustrations. 7-in. × 4½-in.

(Macmillan & Co. Price 1/6.)

This little book belongs to Macmillan's series of First Books of Science, and, according to the preface, has been

written with the object of inducing young students to take up the science of geology seriously. As a first book on the subject we think it fulfils its purpose admirably, and is well calculated to infuse beginners with enthusiasm for this branch of natural history. Since geology is largely a science of outdoor observation, much attention is paid in this book to simple outdoor work, combined with indoor experiment; and each chapter is prefaced by a series of questions and suggestions well calculated to stimulate and foster the interest of the student. The whole science is covered in an elementary manner within fifteen chapters. In treatment there is no variation from the well-established methods of geological primers. An apologetic preface states that the writing of the book has been done in odd hours snatched from a busy life, and that there must be many imperfections. We have noticed, however, very few statements to which exception might be taken, and only one serious misprint (on page 15). There are a number of new illustrations of various geological features, expecially from the North of England. G. W. T.

An Introduction to Geology.—By C. I. Gardiner, M.A., F.G.S. 186 pages. 46 illustrations. 7½-in. × 5-in.

(G. Bell & Sons. Price 2/6 net.)

According to the preface, this book is not a textbook, but is merely designed to lead the general reader up to the textbook. It proposes to deal with matters of general interest which come into the domain of geological science, and therefore approaches the subject as a branch of natural history. The foundations are laid by a short *résumé* of the life and work of Werner, Hutton, William Smith, and Lyell. The treatment then proceeds on the familiar lines laid down in generations of geological textbooks. The account of the stratified rocks is much condensed in view of the avowed object of the book, and of the fact that the serious student can always obtain a more or less detailed account of his own district in Geological Survey memoirs or elsewhere. Owing to their popular appeal, the subjects of scenery, glaciers, caves, coal, and volcanoes are each given a chapter, and expanded to an extent that would be incommensurate with their relative importance in a more formal textbook. There are few misstatements of fact. The only one of any importance is the implication that the Torridon Sandstone is of marine origin (page 47). The Survey Memoir on the North-western Highlands only commits itself to the statement that "the conditions of deposit were probably those of a rapid accumulation in shallow water near a shore line, subject to violent currents and the influx of flood or stream-borne materials"; but the characters of the Torridon Sandstone point unmistakably to terrestrial accumulation under arid or sub-arid conditions, which might have permitted of deposition as described in the memoir.

Misprints are few: "false-bedding" (page 67), "evaporates" (page 132), are misspelt, as is also the term "Rhynchonella" (page 79). The style aims at being simple and understandable, but occasionally overshoots the mark, and becomes somewhat schoolboyish. This may probably account for a clumsiness of construction which causes a statement concerning the Cinque Ports to read contradictorily (page 24). The illustrations are excellent, and include many new photographs of British geological features by Professor S. H. Reynolds.

G. W. T.

PHILOSOPHY.

The Ego and its Place in the World.—By CHARLES GRAY SHAW. 523 pages. 8½-in. × 5½-in.

(Allen & Unwin. Price 12/6 net.)

Like so many works on philosophy, this book is too long. Consequently, its character is marred by a certain diffuseness and indefiniteness. Notwithstanding, however, it is an interesting contribution to the problem of existence, and has much in it of considerable value. But one does wish that philosophers would learn to appreciate the effectiveness of concentration, and cultivate terseness.

Mr. Shaw, I think, owes a good deal to Nietzsche and Stirner, especially the latter. Nietzsche, perhaps, is the most maligned of any philosophical writer at the present day—one who cannot accept his views, and can see the canker of his insanity therein, must at least admit that—and it is well that, in the reäction from his doctrines, sight should not be lost of the value of the Ego. Hence there is a real need for this book, which is written in a sane and broad-minded spirit that the earlier advocates of the supreme value of the Ego lacked.

Mr. Shaw's philosophy is optimistic, its optimism being of a rather stern and definitely intellectualist nature. The self is redeemed through reality; in the life of intellect convincing peace is found. But what is reality? One of the outstanding merits of Mr. Shaw's work is that it recognises grades or degrees of being. The world of appearance, the phenomenal world which is the place of joy, the world of activity, the causal world which is the place of work—both are valid ways of viewing being. But, ultimately, if our philosophy is to be complete, we must transcend these and approach the world of reality—the substantial world, which Mr. Shaw well calls the place of truth. Truth is that which the self can neither transcend nor subdue, but in submitting to it, in uniting itself to it, finds its true place in the world.

There is much in the book that I should like to discuss if space permitted—the question, for instance, of Mr. Shaw's, as opposed to the hedonistic concept of value. But I can do no more than recommend all who are interested in the problems of philosophy to read the book for themselves: it contains much food for thought—mellow and stimulating.

H. S. REDGROVE.

NOTICES.

THE ARTS IN EARLY ENGLAND.—In Mr. Murray's Quarterly List for July the third and fourth volumes of "The Arts in Early England," by Professor Baldwin Brown, are promised. They will deal with Anglo-Saxon art and industry in the pagan period.

SOUTH-WEST AFRICA.—In the current number of *The Bulletin of the Imperial Institute* there is a most useful article on German South-west Africa, giving details of its position and climate, its output of diamonds and of copper, as well as details with regard to its resources generally.

ARTIFICIAL PRODUCTION OF RAIN IN QUEENSLAND.—A correspondent in *The Brisbane Courier* speaks of experiments conducted in Queensland and in Japan, and calls attention to the fact that last year the Radio-telegraph Engineer to the Commonwealth, Mr. Balsillie, patented a process for producing rain. The matter has also for a number of years engaged the attention of Sir Oliver Lodge, and, in reply to questions put to him by a Queensland farmer a few months ago, Sir Oliver said that the idea of producing rain by means of electric currents driven cloudward had engaged his thought thirty years ago, when he lectured before the British Association at Montreal on the subject. Since then he has conducted experiments on a larger scale; but what he desired was to see it tested on a still larger scale, and he has sought methods whereby large quantities of electricity can be discharged into the atmosphere from elevations, not only for the purpose of bringing rain, but of locally clearing away mist and fog; a process which he regards as more probable, indeed, certainly possible.

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